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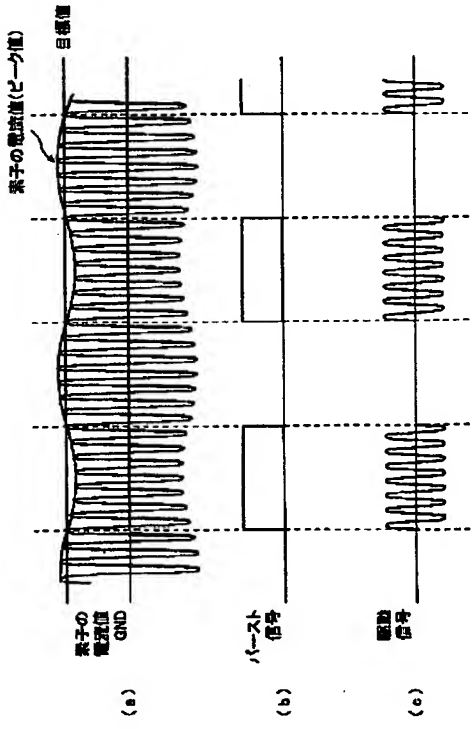
(54)【発明の名称】　アクチュエータ及びその駆動方法

(57)【要約】
【課題】　圧電素子などの変位素子に交流駆動信号を印加して変位素子を振動させ、被駆動部材を所定方向に移動させるアクチュエータにおいて、低速駆動、電池容量の有効利用及び動作の安定をはかる。
【解決手段】　変位素子の振動の振幅に関する情報、例えば圧電素子に流れる電流をモニタし、電流のピーク値が目標値いかになったときに駆動信号を印加を開始し、目標値よりも高くなったときに駆動信号の印加を停止する。



【特許請求の範囲】

【請求項１】　複数の変位素子を各変位素子の変位が合成されるように配置し、前記変位素子の変位合成部分を被駆動部材に加圧接触させることにより被駆動部材を駆動するアクチュエータであって、

少なくとも１つの変位素子の変位に関する情報を検出する変位検出部と、前記変位検出部により検出された情報を少なくとも１つの目標値と比較する比較部と、前記比較部による比較結果を用いて前記変位素子に駆動信号を印加する印加時間及び休止時間を制御する制御部とを具備することを特徴とするアクチュエータ。

【請求項２】　前記目標値は１つであり、前記情報が前記目標値よりも高くなったときに駆動信号の印加を休止させ、前記情報が前記目標値以下になったときに駆動信号の印加を開始することを特徴とする請求項１記載のアクチュエータ。

【請求項３】　前記目標値は第１目標値及び第１目標値よりも低い第２目標値であり、前記情報が前記第１目標値よりも高くなったときに駆動信号の印加を休止させ、前記情報が前記第２目標値以下になったときに駆動信号の印加を開始することを特徴とする請求項１記載のアクチュエータ。

【請求項４】　前記目標値は少なくとも第１変位素子及び第２変位素子の２つの変位素子についてそれぞれ少なくとも１つ設定され、前記変位検出部は目標値が設定された第１変位素子及び第２変位素子についてそれぞれ変位に関する情報を検出し、前記比較部は第１変位素子及び第２変位素子についてそれら変位素子の情報と目標値とを比較し、前記制御部は前記第１変位素子に関する情報が目標値よりも高くなったときに駆動信号の印加を休止させ、前記第２変位素子に関する情報が目標値以下になったときに駆動信号に印加を開始することを特徴とする請求項１記載のアクチュエータ。

【請求項５】　前記複数の変位素子のうち、少なくとも１つの変位素子を他の変位素子の振動により励振させることを特徴とする請求項１から４のいずれかに記載のアクチュエータ。

【請求項６】　前記変位素子の変位に関する情報は、前記変位素子の振幅に関する情報であることを特徴とする請求項１から５のいずれかに記載のアクチュエータ。

【請求項７】　前記変位素子は圧電素子であり、前記変位素子の振幅に関する情報として、前記変位素子に流れる電流値を検出することを特徴とする請求項６記載のアクチュエータ。

【請求項８】　前記変位素子に駆動信号を印加する印加時間及び休止時間は、前記駆動信号の周期と同期していることを特徴とする請求項１から７のいずれかに記載のアクチュエータ。

【請求項９】　複数の変位素子の変位を合成し、前記変位素子の変位合成部分を被駆動部材に加圧接触させることにより被駆動部材を駆動するアクチュエータの駆動方法であって、

少なくとも１つの変位素子の変位に関する情報を検出し、検出された情報を少なくとも１つの目標値と比較し、比較結果を用いて前記変位素子に駆動信号を印加する印加時間及び休止時間を制御することを特徴とするアクチュエータの駆動方法。

【請求項１０】　前記目標値を１つとし、前記情報が前記目標値よりも高くなったときに駆動信号の印加を休止させ、前記情報が前記目標値以下になったときに駆動信号の印加を開始することを特徴とする請求項９記載のアクチュエータの駆動方法。

【請求項１１】　前記目標値を第１目標値及び第１目標値よりも低い第２目標値とし、前記情報が前記第１目標値よりも高くなったときに駆動信号の印加を休止させ、前記情報が前記第２目標値以下になったときに駆動信号の印加を開始することを特徴とする請求項９記載のアクチュエータの駆動方法。

【請求項１２】　前記目標値は少なくとも第１変位素子及び第２変位素子の２つの変位素子についてそれぞれ少なくとも１つ設定し、目標値が設定された第１変位素子及び第２変位素子についてそれぞれ変位に関する情報を検出し、第１変位素子及び第２変位素子についてそれら変位素子の情報と目標値とを比較し、前記第１変位素子に関する情報が目標値よりも高くなったときに駆動信号の印加を休止させ、前記第２変位素子に関する情報が目標値以下になったときに駆動信号に印加を開始することを特徴とする請求項９記載のアクチュエータの駆動方法。

【請求項１３】　前記複数の変位素子のうち、少なくとも１つの変位素子に駆動信号を印加して振動させ、他の少なくとも１つの変位素子を前記変位素子の振動により励振させることを特徴とする請求項９から１２のいずれかに記載のアクチュエータの駆動方法。

【請求項１４】　前記変位素子の変位に関する情報として、前記変位素子の振幅に関する情報を検出することを特徴とする請求項９から１３のいずれかに記載のアクチュエータの駆動方法。

【請求項１５】　前記変位素子として圧電素子を用い、前記変位素子の振幅に関する情報として、前記変位素子に流れる電流値を検出することを特徴とする請求項１４記載のアクチュエータの駆動方法。

【請求項１６】　前記変位素子に駆動信号を印加する印加時間及び休止時間を、前記駆動信号の周期と同期させることを特徴とする請求項９から１５のいずれかに記載のアクチュエータの駆動方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、圧電素子などの変位素子を用いたアクチュエータ及びその駆動方法に関す

る。

【０００２】

【従来の技術】従来より、圧電素子を用いたアクチュエータ（超音波モータ）において速度制御及び電池容量の有効利用を目的として、バースト変調駆動（間欠駆動）が行われている。

【０００３】例えば特公平７－８９７４８号公報には、バースト信号（交流電圧駆動信号）の周波数やデューティ比を変化させて速度制御を行う技術が示されている。また、特許第２８３１１６号には、駆動電圧の連続印加時間の下限値を設定し、印加時間が下限値に達するまでは印加時間を変化させ、印加時間が下限値に達した後は休止時間を変化させることにより速度を制御する技術が示されている。さらに、特許第３００５８６５号には、バースト信号のディユーティ比を変化させることにより、電池容量の利用率を向上させる技術が示されている。

【０００４】

【発明が解決しようとする課題】しかしながら、上記従来技術はいずれもバースト変調駆動によるアクチュエータの速度制御又は電池容量の有効利用に関するものであり、バースト変調駆動によるアクチュエータの出力を安定化する技術は、現在のところ知られていない。

【０００５】本発明は、上記従来例の問題点を解決するためになされたものであり、バースト変調駆動により出力を安定化させたアクチュエータ及びその駆動方法を提供することを目的としている。

【０００６】

【課題を解決するための手段】上記目的を達成するため、本発明のアクチュエータは、複数の変位素子を各変位素子の変位が合成されるように配置し、前記変位素子の変位合成部分を被駆動部材に加圧接触させることにより被駆動部材を駆動するアクチュエータであって、少なくとも１つの変位素子の変位に関する情報を検出する変位検出部と、前記変位検出部により検出された情報を少なくとも１つの目標値と比較する比較部と、前記比較部による比較結果を用いて前記変位素子に駆動信号を印加する印加時間及び休止時間を制御する制御部とを具備することを特徴とする。

【０００７】上記構成において、前記目標値は１つであり、前記情報が前記目標値よりも高くなったときに駆動信号の印加を休止させ、前記情報が前記目標値以下になったときに駆動信号の印加を開始することが好ましい。

【０００８】また、前記目標値は第１目標値及び第１目標値よりも低い第２目標値であり、前記情報が前記第１目標値よりも高くなったときに駆動信号の印加を休止させ、前記情報が前記第２目標値以下になったときに駆動信号の印加を開始することが好ましい。

【０００９】さらに、前記目標値は少なくとも第１変位素子及び第２変位素子の２つの変位素子についてそれぞれ少なくとも１つ設定され、前記変位検出部は目標値が設定された第１変位素子及び第２変位素子についてそれぞれ変位に関する情報を検出し、前記比較部は第１変位素子及び第２変位素子についてそれら変位素子の情報と目標値とを比較し、前記制御部は前記第１変位素子に関する情報が目標値よりも高くなったときに駆動信号の印加を休止させ、前記第２変位素子に関する情報が目標値以下になったときに駆動信号に印加を開始することが好ましい。

【００１０】さらに、前記複数の変位素子のうち、少なくとも１つの変位素子を他の変位素子の振動により励振させることが好ましい。

【００１１】さらに、前記変位素子の変位に関する情報は、前記変位素子の振幅に関する情報であることが好ましい。

【００１２】さらに、前記変位素子は圧電素子であり、前記変位素子の振幅に関する情報として、前記変位素子に流れる電流値を検出することが好ましい。

【００１３】さらに、前記変位素子に駆動信号を印加する印加時間及び休止時間は、前記駆動信号の周期と同期していることが好ましい。

【００１４】一方、本発明のアクチュエータの駆動方法は、複数の変位素子の変位を合成し、前記変位素子の変位合成部分を被駆動部材に加圧接触させることにより被駆動部材を駆動するアクチュエータの駆動方法であって、少なくとも１つの変位素子の変位に関する情報を検出し、検出された情報を少なくとも１つの目標値と比較し、比較結果を用いて前記変位素子に駆動信号を印加する印加時間及び休止時間を制御することを特徴とする。

【００１５】上記方法において、前記目標値を１つとし、前記情報が前記目標値よりも高くなったときに駆動信号の印加を休止させ、前記情報が前記目標値以下になったときに駆動信号の印加を開始することが好ましい。

【００１６】また、前記目標値を第１目標値及び第１目標値よりも低い第２目標値とし、前記情報が前記第１目標値よりも高くなったときに駆動信号の印加を休止させ、前記情報が前記第２目標値以下になったときに駆動信号の印加を開始することが好ましい。

【００１７】さらに、前記目標値は少なくとも第１変位素子及び第２変位素子の２つの変位素子についてそれぞれ少なくとも１つ設定し、目標値が設定された第１変位素子及び第２変位素子についてそれぞれ変位に関する情報を検出し、第１変位素子及び第２変位素子についてそれら変位素子の情報と目標値とを比較し、前記第１変位素子に関する情報が目標値よりも高くなったときに駆動信号の印加を休止させ、前記第２変位素子に関する情報が目標値以下になったときに駆動信号に印加を開始することが好ましい。

【００１８】さらに、前記複数の変位素子のうち、少なくとも１つの変位素子に駆動信号を印加して振動させ、

5

他の少なくとも１つの変位素子を前記変位素子の振動により励振させることが好ましい。

【００１９】さらに、前記変位素子の変位に関する情報として、前記変位素子の振幅に関する情報を検出することが好ましい。

【００２０】さらに、前記変位素子として圧電素子を用い、前記変位素子の振幅に関する情報として、前記変位素子に流れる電流値を検出することが好ましい。

【００２１】さらに、前記変位素子に駆動信号を印加する印加時間及び休止時間を、前記駆動信号の周期と同期させることが好ましい。

【００２２】

【発明の実施の形態】本発明の一実施形態に係るアクチュエータについて説明する。本実施形態に係るアクチュエータであるトラス型アクチュエータの構成を図１に示す。

【００２３】図１に示すように、駆動ユニットは、互いに所定角度（例えば９０度）をなすように配置された２つの積層型の第１圧電素子１０Ａ及び第２圧電素子１０Ｂと、第１圧電素子１０Ａと第２圧電素子１０Ｂの交差側端部に接着剤などにより接合されたチップ部材（駆動部材）２０と、第１圧電素子１０Ａ及び第２圧電素子１０Ｂの基端部が接着剤などにより固定され、第１圧電素子１０Ａ及び第２圧電素子１０Ｂを保持するベース部材３０と、チップ部材２０をロータ４０の表面に当接させるための加圧力を発生する加圧部材（コイルばねや板ばねなどの弾性体）４５などで構成されている。

【００２４】第１圧電素子１０Ａ及び第２圧電素子１０Ｂの詳細を図２に示す。なお、両者は実質的に同一構成である。各圧電素子１０Ａ，１０Ｂは、それぞれＰＺＴ（チタン酸ジルコン酸鉛）などの圧電特性を示す複数のセラミック薄板１１と電極１２，１３を交互に積層したものであり、各セラミック薄板１１と電極１２，１３とは接着剤などにより固定されている。１つおきに配置された各電極群１２及び１３は、それぞれ信号線１４，１５を介して駆動電源１６に接続されている。信号線１４と１５の間に所定の電圧を印加すると、電極１２と１３に挟まれた各セラミック薄板１１には、その積層方向に電界が発生し、その電界は１つおきに同じ方向である。従って、各セラミック薄板１１は、１つおきに分極の方向が同じになる（隣り合う２つのセラミック薄板１１の分極方向は逆となる）ように積層されている。なお、各圧電素子１０Ａ，１０Ｂの両端部には、保護層１７が設けられている。

【００２５】駆動電源１６により直流の駆動電圧を各電極１２と１３の間に印加すると、全てのセラミック薄板１１が同方向に伸び又は縮み、各圧電素子１０Ａ，１０Ｂが全体として伸縮する。電界が小さく、かつ変位の履歴が無視できる領域では、各電極１２と１３の間に発生する電界と各圧電素子１０Ａ，１０Ｂの変位は、ほぼ直線的な関係と見なすことができる。

6

【００２６】一方、駆動電源１６により交流の駆動電圧（交流信号）を各電極１２と１３の間に印加すると、その電界に応じて各セラミック薄板１１は同方向に伸縮を繰り返し、各圧電素子１０Ａ，１０Ｂが全体として伸縮を繰り返す。各圧電素子１０Ａ，１０Ｂには、その構造や電気的特性により決定される固有の共振周波数が存在する。交流の駆動電圧の周波数が各圧電素子１０Ａ，１０Ｂの共振周波数と一致すると、インピーダンスが低下し、各圧電素子１０Ａ，１０Ｂの変位が増大する。各圧電素子１０Ａ，１０Ｂは、その外形寸法に対して変位が小さいため、低い電圧で駆動するためには、この共振現象を利用することが望ましい。

【００２７】チップ部材２０の材料としては、安定して高い摩擦係数が得られ、かつ耐摩耗性に優れたタングステンなどが好ましい。ベース部材３０の材料としては、製造が容易で、かつ強度に優れたステンレス鋼などが好ましい。また、接着剤としては、接着力及び強度に優れたエポキシ系樹脂などが好ましい。

【００２８】第１圧電素子１０Ａ及び第２圧電素子１０Ｂをそれぞれ位相差を有する交流信号で駆動するか又はいずれか一方の圧電素子１０Ａ又は１０Ｂを駆動することにより、チップ部材２０が楕円軌道又は円軌道を描くように駆動することができる。このチップ部材２０を、例えば所定の軸Ｌの周りに回転可能なロータ４０の円筒面に押しつけると、チップ部材２０の楕円運動又は円運動をロータ４０の回転運動に変換することが可能となる。あるいは、チップ部材２０を、例えば棒状部材（図示せず）の平面部に押しつけることにより、チップ部材２０の楕円運動又は円運動を棒状部材の直線運動に変換することが可能となる。ロータ４０の材料としては、アルミニウムなどの軽量金属が好ましく、チップ部材２０との摩擦による摩耗を防止するため、表面にタフトライド処理やアルマイト処理などを施すことが好ましい。

【００２９】図１に示すようなトラス型アクチュエータの駆動方法としては、２つの圧電素子１０Ａと１０Ｂにそれぞれ所定の位相差を有する駆動信号を印加し、２つの圧電素子１０Ａと１０Ｂを同時に駆動する方法と、いずれか一方の圧電素子（駆動側素子）１０Ａ又は１０Ｂを駆動し、他方の圧電素子（従動側素子）１０Ｂ又は１０Ａに位相の遅れた振動又は位相の進んだ振動を伝達する駆動方法が考えられる。本実施形態のアクチュエータでは、後者の駆動方法を採用している。

【００３０】いずれか一方の圧電素子１０Ａ又は１０Ｂのみを駆動する場合、駆動素子となる圧電素子１０Ａ又は１０Ｂの振動と受動素子となる圧電素子１０Ｂ又は１０Ａの振動の位相差は駆動信号の周波数により変化し、また１つの圧電素子１０Ａと１０Ｂの交差部に設けられたチップ部材２０の軌跡の形状は、楕円振動の式（Lissajousの式）に従い、これら２つの圧電素子１０Ａと１

7

０Ｂの振動の位相差によって変化する。

【００３１】周知のように、圧電素子に対して電圧を印加すれば電界の方向に伸縮し、また圧電素子に対して所定方向に引張力又は圧縮力を加えると、その方向に電圧を発生する。従って、駆動側素子に流れる電流及び従動側素子に発生する電圧により流れる電流をモニタすることにより、駆動側素子及び従動側素子の振動状態を知ることができる。

【００３２】次に、一方の圧電素子（駆動側素子）１０Ａ又は１０Ｂに交流電圧（正弦波）駆動信号を入力して駆動し、他方の圧電素子（従動側素子）１０Ｂ又は１０Ａを振動させた場合における各圧電素子１０Ａ及び１０Ｂに流れる電流値の変化を図３及び図４に示す。図３は駆動側素子に駆動信号を印加し始めた直後（起動時）の電流波形を示し、図４は駆動側素子への駆動信号の印加を停止した直後（停止時）の電流波形を示す。これらの電流波形は、各圧電素子１０Ａ及び１０Ｂにそれぞれ直列に接続した抵抗を用いて検出したものである。

【００３３】図３からわかるように、起動時には、駆動側素子及び従動側素子共に所定の振幅に達するまでの立ち上がりに時間を要する。また、駆動側素子は駆動信号の印加開始から比較的すぐに振動を開始するが、従動側素子が振動を開始するまでにしばらく時間を要する。また、図４からわかるように、停止時においても同様に、駆動側素子及び従動側素子共に所定の振幅に減衰するまでの立ち下がりに時間を要する。また、従動側素子は駆動側素子に比べて立ち下がりが遅く、駆動側素子がほぼ減衰してもまだ所定の振幅で振動している。このように、一方の圧電素子のみを駆動する場合、共振現象を利用するため、各圧電素子の振動の立ち上がりに時間を要し、かつ駆動信号の停止後も各圧電素子の振動は一定時間持続する。

【００３４】次に、本実施形態のアクチュエータにおけるバースト変調駆動について、図５及び図６を参照しつつ説明する。各図において、（ａ）はモニタされる圧電素子１０Ａ又は１０Ｂに流れる電流値、（ｂ）はバースト信号、（ｃ）は圧電素子に実際に印加される駆動信号をそれぞれ表す。なお、モニタされる圧電素子は駆動側素子及び従動側素子のいずれであってもよい。

【００３５】バースト変調駆動は、駆動側素子に印加する駆動信号を停止しても一定時間各圧電素子の振動が持続する現象を利用したものである。図５に示す駆動例は制御の目標値を１つだけ設定した場合であり、圧電素子１０Ａ又は１０Ｂに流れる電流値が所定値よりも高くなるまで駆動信号を連続して印加し、所定値を超えた時点で駆動信号の印加を停止し、さらに電流値が所定値以下になったときに駆動信号の印加を再開する。図５に示す駆動例では、モニタされる圧電素子に流れる交流電流値のピーク値が目標値以下の間バースト信号が出力され、バースト信号が出力されている間だけ駆動信号が駆動側

8

素子に印加される。

【００３６】また、図６に示す駆動例は制御の目標値を２つ設定した場合であり、圧電素子１０Ａ又は１０Ｂに流れる電流値が第１所定値よりも高くなるまで駆動信号を連続して印加し、第１所定値を超えた時点で駆動信号の印加を停止し、さらに電流値が第１所定値よりも小さい第２所定値以下になったときに駆動信号の印加を再開する。図６に示す駆動例では、モニタされる圧電素子に流れる交流電流値のピーク値が第２目標値以下になった時点から第１目標値を超えるまでの間バースト信号が出力され、バースト信号が出力されている間だけ駆動信号が駆動側素子に印加される。これらの動作を繰り返すことにより、見かけ上アクチュエータは連続して振動しているが、駆動信号は間欠的にしか供給されず、アクチュエータの低速駆動及び電池容量の有効利用が可能となる。さらに、モニタされる圧電素子に流れる電流のピーク値が一定の範囲内となるように制御されるため、アクチュエータによる被駆動部材の速度やトルクなどを安定化させることができる。

【００３７】次に、本実施形態における駆動回路のブロック構成の一例を図７に示す。図７に示す例では、圧電素子１０Ａ又は１０Ｂに印加される駆動信号として正弦波電圧信号を用いる。

【００３８】第１圧電素子１０Ａ及び第２圧電素子１０Ｂには、それぞれ各圧電素子１０Ａ，１０Ｂに流れる電流を検出するために抵抗５１Ａ及び５１Ｂが直列接続されている。各抵抗５１Ａ及び５１Ｂの端子電圧は、それぞれ第１電流検出部５２Ａ及び第２電流検出部５２Ｂに入力され、例えば図３及び図４に示すような正弦波電流波形として検出される。各電流検出部５２Ａ，５２Ｂは、それぞれ増幅器及びゼロクロスコンマレータなどで構成されており、正弦波電流波形を方形波に波形整形した後、方形波信号を位相差検出部５３に入力する。位相差検出部５３は、例えばエクスクルーシブオア回路及びローパスフィルタなどで構成され、入力された２つの信号の位相差を検出する。

【００３９】位相差検出部５３により得られたアナログの位相差信号は、演算処理部（ＭＰＵ）６０のＡ／Ｄ変換部６１に入力され、ディジタル信号化された後、位相差比較部（Ｃｏｍｐ）６２により目標位相差（Ｒｅｆ）と比較される。位相差比較部６２による比較結果（目標位相差と実際に位相差との差）はＤ／Ａ変換部６３に入力され、ディジタル信号化された後、電圧制御発振器（ＶＣＯ）５４に入力される。なお、演算処理部６０には入出力制御部（Ｉ／Ｏ）６４が設けられているが、その機能は後述する。

【００４０】発振器５４は、演算処理部６０からの出力に応じてその発振周波数を調節する。周波数が調節された正弦波信号は、第１～第４スイッチ素子５５Ａ～５５Ｄを介して第１増幅器５６Ａ及び第２増幅器５６Ｂに入

力され、所定の振幅に増幅される。各スイッチ５５Ａ～５５Ｄはそれぞれトランジスタなどの素子で構成され、例えばハイレベル又は”１”に相当する信号が入力されるとオンし、ローレベル又は”０”に相当する信号が入力されるとオフするように構成されているものとする。なお、以下の説明では、便宜上「ハイレベル信号」及び「ローレベル信号」とする。

【００４１】第１増幅器５６Ａにより増幅された駆動信号は第１圧電素子１０Ａに印加され、また第２増幅器５６Ｂにより増幅された駆動信号が第２圧電素子１０Ｂに印加される。このように、第１圧電素子１０Ａと第２圧電素子１０Ｂの実際の振動状態を電流値などを用いて検出し、それらの振動の位相差を目標位相差に一致するように駆動信号の周波数をフィードバック制御することにより、チップ部材２０の軌跡を所望する形状に近似させることが可能となる。

【００４２】なお、スイッチ素子５５Ａ～５５Ｄは、第１圧電素子１０Ａと第２圧電素子１０Ｂのいずれを駆動側素子及びいずれを従動側素子とするかの切り替え、及びバースト変調制御の際の駆動信号の印加開始及び停止を制御するために用いられる。また、本実施形態ではいずれか一方の圧電素子１０Ａ又は１０Ｂのみを駆動し他方の圧電素子は従動させるので、第１圧電素子１０Ａと第２圧電素子１０Ｂの両方同時に駆動信号が印加されるようにスイッチ素子５５Ａ～５５Ｄが制御されることはない。

【００４３】一方、第１電流検出部５２Ａの出力は第１ピーク検出部５７Ａに入力され、また第２電流検出部５２Ｂの出力は第２ピーク検出部５７Ｂに入力される。各ピーク検出部５７Ａ及び５７Ｂは、各電流検出部５２Ａ及び５２Ｂにより検出された図５（ａ）又は図６（ａ）に示すような正弦波信号からそれらのピークを検出する。各ピーク検出部５７Ａ及び５７Ｂにより検出されたピーク値信号は、それぞれ第１電流値比較部５８Ａ及び第２電流値比較部５８Ｂに入力され、目標値と比較される。一例として、各電流値比較部５８Ａ及び５８Ｂは、検出された電流のピーク値が目標値（場合によっては２つの目標値のいずれか）よりも高い場合ローレベル信号を出力し、目標値以下の場合ハイレベル信号を出力する。各電流値比較部５８Ａ及び５８Ｂは常時各圧電素子１０Ａ及び１０Ｂに流れる電流のピーク値と所定の目標値とを比較し、モニタ素子切り替え部７０に出力する。

【００４４】モニタ素子切換部７０は、例えば第１ＡＮＤ回路７１、第２ＡＮＤ回路７２及びＯＲ回路７３で構成されており、第１電流値比較部５８Ａからの出力信号は第１ＡＮＤ回路７１に入力され、第２電流値比較部５８Ｂからの出力信号は第２ＡＮＤ回路７２に入力される。また、第１ＡＮＤ回路７１及び第２ＡＮＤ回路７２は、それぞれ演算処理部６０の入出力制御部６４に接続されている。入出力制御部６４は、第１圧電素子１０Ａと第２圧電素子１０Ｂのうちモニタ素子として使用する側に接続されているＡＮＤ回路７１又は７２に対してハイレベル信号を出力し、他方にはローレベル信号を出力する。例えば、第１圧電素子１０Ａをモニタ素子として使用する場合、入出力制御部６４は第１ＡＮＤ回路７１に対してハイレベル信号を出力し、第２圧電素子１０Ｂにはローレベル信号を出力する。従って、第２電流値比較部５８Ｂからハイレベル信号が出力されても第２ＡＮＤ回路７２はオンせず、第２ＡＮＤ回路７２からはローレベル信号が出力される。これに対して、第１圧電素子１０Ａに流れる電流のピーク値が目標値以下になると、第１電流値比較部５８Ａからハイレベル信号が出力されるので第１ＡＮＤ回路７１がオンし、第１ＡＮＤ回路７１からハイレベル信号が出力される。ＯＲ回路７３には、第１ＡＮＤ回路７１からハイレベル信号が入力され、また第２ＡＮＤ回路７２からローレベル信号がそれぞれ入力されるので、ＯＲ回路７３からはハイレベル信号が、駆動素子切換部８０に出力される。

【００４５】駆動素子切換部８０は、例えば第３ＡＮＤ回路８１及び第４ＡＮＤ回路８２で構成されており、ＯＲ回路７３からの出力は第３ＡＮＤ回路８１及び第４ＡＮＤ回路８２に入力される。また、第３ＡＮＤ回路８１及び第４ＡＮＤ回路８２は、それぞれ演算処理部６０の入出力制御部６４に接続されている。入出力制御部６４は、第１圧電素子１０Ａと第２圧電素子１０Ｂのうち駆動側素子として使用する側に接続されているＡＮＤ回路８１又は８２に対してハイレベル信号を出力し、他方にはローレベル信号を出力する。例えば、第１圧電素子１０Ａを駆動側素子として使用する場合、入出力制御部６４は第３ＡＮＤ回路８１に対してハイレベル信号を出力し、第２圧電素子１０Ｂにはローレベル信号を出力する。従って、ＯＲ回路７３からハイレベル信号が出力されても第４ＡＮＤ回路８２はオンせず、第４ＡＮＤ回路８２からはローレベル信号を出力される。これに対して、ＯＲ回路７３からハイレベル信号が出力されると、第３ＡＮＤ回路８１がオンし、第３ＡＮＤ回路８１からハイレベル信号が出力される。

【００４６】第３ＡＮＤ回路８１は、発振器５４と第１増幅器５６Ａとの間に設けられた第１スイッチ素子５５Ａに接続されており、第４ＡＮＤ回路８２は、発振器５４と第２増幅器５６Ｂとの間に設けられた第３スイッチ素子５５Ｃに接続されている。また、入出力制御部６４は、グラウンドと第１増幅器５６Ａ及び第２増幅器５６Ｂの間に設けられた第２スイッチ素子５５Ｂ及び第４スイッチ素子５５Ｄに接続されている。

【００４７】第３ＡＮＤ回路８１からハイレベル信号が出力されると、第１スイッチ素子５５Ａがオンし、発振器５４から出力される正弦波信号が第１増幅器５６Ａに入力され、所定の振幅に増幅されて駆動信号として第１圧電素子１０Ａに印加される。第３ＡＮＤ回路８１から

ローレベル信号が出力されると、第１スイッチ素子５５Ａがオフし、発振器５４から出力される正弦波信号が第１増幅器５６Ａに入力されなくなり、第１圧電素子１０Ａへの駆動信号の印加が停止される。なお、前述の駆動素子切換部８０の構成から、第１スイッチ素子５５Ａと第３スイッチ素子５５Ｃが同時にオンすることはない。また、第２スイッチ素子５５Ｂ及び第４スイッチ素子５５Ｄは、それぞれ第１圧電素子１０Ａ又は第２圧電素子１０Ｂが従動側素子として使用される場合に、従動側素子に貯まっている電荷を放電するために用いられる。

【００４８】このような回路構成により、第１圧電素子１０Ａと第２圧電素子１０Ｂのいずれかを駆動側素子とし、他方を従動側素子として駆動しつつ、チップ部材２０が所定の軌跡を描くように駆動信号の周波数をフィードバック制御することができると共に、いずれかの素子に流れる電流をモニタしながら駆動信号の印加開始及び停止を制御するバースト変調駆動を行うことができる。

【００４９】なお、上記説明では、モニタする圧電素子１０Ａ又は１０Ｂの電流値として交流電流の正のピーク値を用い、この値と目標値とを比較したが、これに限定されるものではなく、電流の実効値や負のピーク値など変位素子（圧電素子）の振幅に関する情報であれば何でもよい。さらに、駆動側素子又は従動側素子のいずれかに目標値を設定し、その素子の振幅に関する情報をモニタするように構成したが、これに限定されるものではなく、駆動側素子及び従動側素子の両方にそれぞれ１つ又は２つの目標値を設定し、駆動側素子及び従動側素子の両方をモニタするように構成してもよい。その場合、例えば駆動側素子の振幅に関する情報を用いてバースト信号を立ち上げ、従動側素子の振幅に関する情報を用いてバースト信号を立ち下げるように構成してもよい。その場合、入出力制御部６４は、モニタ素子切換部７０の第１ＡＮＤ回路７１と第２ＡＮＤ回路７２に入力する信号を交互に切り替えればよい。これらの応用は以下の変形例においても同様である。

【００５０】次に、本実施形態における駆動回路の変形例のブロック構成を図８に示す。また、図８中のＨブリッジ・ドライバ制御部の詳細を図９に、Ｈブリッジ・ドライバの詳細を図１０に示す。図８～図１０に示す変形例では、圧電素子１０Ａ又は１０Ｂに印加される駆動信号として方形波電圧信号を用いる。なお、上記図７に示す回路と同じ符号を付した構成要素は実質的に同じものであるため、その説明を省略する。

【００５１】図８中、電圧制御発振器５４Ｘは方形波信号を発振し、Ｈブリッジ・ドライバ制御部９０に入力される。また、駆動素子切換部８０の第３ＡＮＤ回路８１及び第４ＡＮＤ回路８２からの出力もＨブリッジ・ドライバ制御部９０に入力される。Ｈブリッジ・ドライバ制御部９０は、第１圧電素子１０Ａに接続された第１Ｈブリッジ・ドライバ１００Ａ及び第２圧電素子１０Ｂに接続された第２Ｈブリッジ・ドライバ１００Ｂをそれぞれ制御する。

【００５２】図９に示すように、Ｈブリッジ・ドライバ制御部９０は、第１～第４のＮＡＮＤ回路９１Ａ～９１Ｄと、インバータ９２で構成されている。発振器５４Ｘからの方形波信号は第１ＮＡＮＤ回路９１Ａ及び第３ＮＡＮＤ回路９１Ｃに直接入力され、またインバータ９２により反転された後、第２ＮＡＮＤ回路９１Ｂ及び第４ＮＡＮＤ回路９１Ｄに入力される。一方、第３ＡＮＤ回路８１の出力は第１ＮＡＮＤ回路９１Ａ及び第２ＮＡＮＤ回路９１Ｂに入力され、第４ＡＮＤ回路８２の出力は第３ＮＡＮＤ回路９１Ｃ及び第４ＮＡＮＤ回路９１Ｄに入力される。

【００５３】従って、例えば駆動側素子として第１圧電素子１０Ａが選択されている場合に、発振器５４Ｘからの方形波信号がハイレベルで、かつ第３ＡＮＤ回路８１からの出力がハイレベルの時に第１ＮＡＮＤ回路９１からローレベル信号が、第２ＮＡＮＤ回路９２からハイレベル信号が、それぞれ第１Ｈブリッジ・ドライバ１００Ａに入力される。逆に、発振器５４Ｘからの方形波信号がローレベルで、かつ第３ＡＮＤ回路８１からの出力がハイレベルの時に第１ＮＡＮＤ回路９１からハイレベル信号が、第２ＮＡＮＤ回路９２からローレベル信号が、それぞれ第１Ｈブリッジ・ドライバ１００Ａに入力される。一方、第４ＡＮＤ回路８２からの信号はローレベルであるので、第３ＮＡＮＤ回路９１Ｃ及び第４ＮＡＮＤ回路９１Ｄからはそれぞれハイレベル信号が出力される。駆動側素子として第２圧電素子１０Ｂが選択されている場合も同様である。

【００５４】次に、Ｈブリッジ・ドライバ１００Ａ，１００Ｂの構成を図１０に示す。第１圧電素子１０Ａと抵抗５１Ａの直列回路又は第２圧電素子１０Ｂと抵抗５１Ｂの直列回路に対して駆動電圧Ｖｃｃの印加の開始及び停止を制御するためのブリッジ回路を構成する第５～第８スイッチ素子１０１Ａ～１０１Ｄ、第５スイッチ素子１０１Ａに接続された第１ＮＯＲ回路１０２Ａ、第７スイッチ素子１０１Ｃに接続された第２ＮＯＲ回路１０２Ｂ、第６スイッチ素子１０１Ｂ及び第８スイッチ素子１０１Ｄにそれぞれ接続されたバッファ１０３Ａ及び１０３Ｂ、各ＮＯＲ回路１０２Ａ及び１０２Ｂに接続された第２及び第３インバータ１０４Ａ及び１０４Ｂなどで構成されている。なお、バッファ１０３Ａ及び１０３Ｂは、トランジスタなどで構成されたスイッチング素子１０１Ｂ及び１０１Ｄのインピーダンスなどを調節するために用いられる。

【００５５】第１ＮＡＮＤ回路９１Ａ又は第３ＮＡＮＤ回路９１Ｃからの出力信号は、第２インバータ１０４Ａを介して第１ＮＯＲ回路１０２Ａに入力されると共に、第２ＮＯＲ回路１０２Ｂに直接入力される。一方、第２ＮＡＮＤ回路９１Ｂ又は第４ＮＡＮＤ回路９１Ｄからの

出力信号は、直接第１NOR回路１０２A及びバッファ１０３Aに入力されると共に、第３インバータ１０４Bを介して第２NOR回路１０２B及びバッファ１０３Bに入力される。

【００５６】第１NAND回路９１A又は第３NAND回路９１Cからの信号がハイレベルかローレベルか、及び第２NAND回路９１B又は第４NAND回路９１Dからの信号がハイレベルかローレベルかの組み合わせに応じた第５～第８スイッチ素子のオン／オフ及び圧電素子１０A又は１０Bの動作状態を以下の表１に示す。な＊お、表１中、信号”X”は第１NAND回路９１A又は第３NAND回路９１Cからの信号を表し、信号”Y”は第２NAND回路９１B又は第４NAND回路９１Dからの信号を表す。また、”H”及び”L”はそれぞれ信号のレベルがハイレベル及びローレベルであることを表し、SW５～SW８はそれぞれ第５～第８スイッチ素子を表す。さらに、「駆動モード」とは圧電素子１０A又は１０Bの状態を表す。

【００５７】

【表１】

信号		スイッチ素子				駆動モード
X	Y	SW5	SW6	SW7	SW8	
L	L	OFF	OFF	OFF	OFF	停止
L	H	ON	OFF	OFF	ON	駆動側素子(正方向充電)
H	L	OFF	ON	ON	OFF	駆動側素子(逆方向充電)
H	H	OFF	ON	OFF	ON	従動側素子又は停止

【００５８】上記変形例では、発振器５４Xにより発振される信号を増幅して駆動信号とし、これを圧電素子１０A又は１０Bに印加するのではなく、上記発振器５４Xからの信号をHブリッジ・ドライバ１００A又は１００Bに供給される駆動電圧Ｖｃｃを圧電素子１０A又は１０Bに印加するためのタイミング信号として用いているので、発振器５４Xによる周波信号をディジタル的に取り扱うことができ、増幅器が不要になるなど、駆動回路の構成を簡単にすることができる。

【００５９】なお、圧電素子１０A又は１０Bに印加される駆動信号は方形波であるが、その周波数は各圧電素子１０A及び１０Bの共振周波数の近傍にあるため、各圧電素子１０A及び１０Bの振動は正弦波的になる。従って、各圧電素子１０A及び１０Bに流れる電流波形も正弦波的になるが、駆動側素子に流れる電流には、駆動信号による突入電流に起因するノイズが重畳される。従って、電流検出部５２A及び５２Bにより検出された電流波形をローパスフィルタ処理することが好ましい。

【００６０】次に、バースト信号と発振器５４又は５４Xから出力される周波数信号との同期及び非同期について説明する。図１１は、同期及び非同期の場合におけるタイミングチャートであり、（ａ）は発振器（VCO）５４Xからの周波数信号（方形波）、（ｂ）は非同期の場合のバースト信号、（ｃ）は非同期の場合の駆動信号、（ｄ）は同期の場合のバースト信号、（ｅ）は同期の場合の駆動信号の各波形を表す。

【００６１】図７及び図８に示す各駆動回路では、バースト信号と発振器５４又は５４Xから出力される周波数信号の同期をとらずに、すなわち非同期で駆動している。上記各駆動回路では、発振器５４又は５４Xから所定周波数の正弦波信号又は方形波信号が連続的に出力されているが、バースト信号が出力されている間だけしか駆動信号が圧電素子１０A又は１０Bに印加されないように構成されている。還元すれば、圧電素子１０A又は１０Bに印加される駆動信号は、図１１（ｃ）に示すように（ａ）の周波数信号と（ｂ）のバースト信号のANDをとったような波形となる。バースト信号と発振器５４又は５４Xから出力される周波数信号とは同期していないので、（ｃ）に示すような発振器５４又は５４Xから出力される周波数信号とは異なる波形の駆動信号が圧電素子に印加される。その場合、（ｃ）の両端のような周期の短い信号が駆動信号に混在すると、圧電素子１０A又は１０Bの振動が若干不安定になるおそれがある。

【００６２】これに対して、（ｄ）に示すようにバースト信号と発振器５４又は５４Xから出力される周波数信号とを同期させると、（ｅ）に示すような発振器５４又は５４Xから出力される周波数信号とは同じ波形の駆動信号が圧電素子に印加される。その結果、圧電素子１０A又は１０Bの振動をより安定化させることができる。

【００６３】バースト信号と発振器５４又は５４Xから出力される周波数信号とを同期させるための回路構成を図１２及び図１３に示す。

【００６４】図１２は、発振器（VCO）５４からの出力信号が正弦波信号である場合における回路構成であり、図７に示す駆動回路のうち駆動信号を生成する部分に、ゼロクロスコンパレータ１１０及びDフリップフロップ（D．FF）１１１を追加し、一部の構成要素を省略して概略的に示したものである。この場合、発振器（VCO）５４の出力信号はゼロクロスコンパレータ１１０にも入力され、ゼロクロスコンパレータ１１０の出

15

力（発振器（ＶＣＯ）５４の出力信号の電圧が”０”になったタイミングを表す）はＤフリップフロップ１１１のクロック端子にタイミング信号として入力される。また、電流値比較部５８Ａ又は５８Ｂの出力はＤフリップフロップ１１１のＤ端子に入力され、Ｄフリップフロップ１１１のＱ端子からの出力を用いてスイッチ素子５５Ａ又は５５Ｃを制御する。その結果、スイッチ素子５５Ａ又は５５Ｃのオン／オフのタイミングが発振器５４からの出力信号の立ち上がり又は立ち下がりと同期する。

【００６５】図１３は、発振器（ＶＣＯ）５４からの出力信号が方形波信号である場合における回路構成であり、図８に示す駆動回路のうち駆動信号を生成する部分に、Ｄフリップフロップ（Ｄ．ＦＦ）１１１を追加し、一部の構成要素を省略して概略的に示したものである。この場合、発振器（ＶＣＯ）５４Ｘの出力信号はＤフリップフロップ１１１のクロック端子にタイミング信号として直接入力される。また、電流値比較部５８Ａ又は５８Ｂの出力はＤフリップフロップ１１１のＤ端子に入力され、Ｈブリッジ・ドライバ制御部９０によりＤフリップフロップ１１１のＱ端子からの出力と発振器（ＶＣＯ）５４Ｘの出力信号のＡＮＤを取り、その信号を用いてＨブリッジ・ドライバ１００Ａ又は１００Ｂを制御する。その結果、スイッチ素子１０１Ａ～１０１Ｄオン／オフのタイミングが発振器５４Ｘからの出力信号の立ち上がり又は立ち下がりと同期する。

【００６６】次に、上記本実施形態のアクチュエータを用いて低速駆動する方法について簡単に説明する。前述のように、圧電素子の振動は、その立ち上がり及び立ち下がりに時間を要する。この特性を利用し、バースト変調駆動時の圧電素子に流れる電流の目標値を、駆動信号を連続して印加する場合の目標値よりも低い値に設定する。そうすると、モニタされる圧電素子の振動の振幅、ひいては駆動祖その振動の振幅が小さい範囲でほぼ一定に維持される。その結果、見かけ上、圧電素子に印加する駆動信号の電圧を下げた場合と同様の駆動速度が得られる。なお、今場合、駆動信号の電圧は一定であるので、増幅器の増幅率を可変にする必要はなく、回路構成を簡単にすることができる。逆に、増幅器の増幅率が可変の場合、低速駆動の制御精度を高くすることができる。

【００６７】なお、上記実施形態の説明ではトラス型アクチュエータについて説明したが、これに限定されるものではなく、超音波振動を利用したその他のアクチュエータに応用することができることは言うまでもない。また、上記実施形態の説明では、２つの圧電素子の交差部分にチップ部材を設け、このチップ部材を被駆動部材であるロータに接触させるように構成したが、これに限定されるものではなく、圧電素子などの変位素子の交差部分を直接被駆動部材に接触させるように構成してもよい。

16

【００６８】さらに、上記実施形態では、いずれか一方の圧電素子に駆動信号を印加して駆動側素子とし、他方の圧電素子に駆動信号を印加せずに従動側素子としたが、これに限定されるものではなく、各圧電素子に駆動信号を同時に印加しつつ、駆動信号を印加する印加時間と休止時間のタイミングを制御するバースト変調駆動を行うように構成してもよい。さらに、圧電素子（変位素子）の数は２つに限定されず、３つ以上であってもよい。その場合、少なくとも１つの圧電素子を従動させるように駆動してもよい。さらに、変位素子としては、図２に示す積層型圧電素子には限定されず、磁歪素子や圧電素子と弾性部材を組み合わせたものなどを用いることができる。

【００６９】

【発明の効果】以上説明したように、本発明のアクチュエータによれば、複数の変位素子を各変位素子の変位が合成されるように配置し、前記変位素子の変位合成部分を被駆動部材に加圧接触させることにより被駆動部材を駆動するアクチュエータであって、少なくとも１つの変位素子の変位に関する情報を検出する変位検出部と、前記変位検出部により検出された情報を少なくとも１つの目標値と比較する比較部と、前記比較部による比較結果を用いて前記変位素子に駆動信号を印加する印加時間及び休止時間を制御する制御部とを具備する。

【００７０】また、本発明のアクチュエータの駆動方法によれば、複数の変位素子の変位を合成し、前記変位素子の変位合成部分を被駆動部材に加圧接触させることにより被駆動部材を駆動するアクチュエータの駆動方法であって、少なくとも１つの変位素子の変位に関する情報を検出し、検出された情報を少なくとも１つの目標値と比較し、比較結果を用いて前記変位素子に駆動信号を印加する印加時間及び休止時間を制御する。

【００７１】すなわち、本発明は、変位素子に駆動信号の印加を開始してもすぐには所定の変位量ならず、所定の変位量に達するまでに一定の時間を要し、その間に変位量が徐々に増大すると共に、駆動信号の印加を停止してもすぐには変位量は０にはならず、変位量が徐々に減衰する性質を利用している。例えば、変位素子の変位量が目標値を超えたときに駆動信号の印加を停止し、変位量が目標値以下になった場合に駆動信号の印加を再開する用に駆動することにより、全動作時間に占める駆動信号の印加時間の割合を小さくし、アクチュエータの消費電力を低減し、電池寿命を伸ばすことができる。また、目標値を低く設定することにより、アクチュエータを見かけ上駆動信号の電圧よりも低い電圧で駆動した場合と同様の駆動速度を得ることができる。さらに、電池は、連続的に出力を取り出すよりも、間欠的に出力を取り出す方が、電池容量を有効に利用することができることから、駆動信号を間欠的に変位素子に供給することにより、電池容量を有効に利用することができる。

【００７２】また、前記目標値を１つとし、前記情報が前記目標値よりも高くなったときに駆動信号の印加を休止させ、前記情報が前記目標値以下になったときに駆動信号の印加を開始するように制御することにより、変位素子の変位量、換言すればアクチュエータの駆動速度又は出力をほぼ一定にすることができる。

【００７３】または、前記目標値を第１目標値及び第１目標値よりも低い第２目標値とし、前記情報が前記第１目標値よりも高くなったときに駆動信号の印加を休止させ、前記情報が前記第２目標値以下になったときに駆動信号の印加を開始するように制御することにより、変位素子の変位量の誤差が許容できる範囲内でほぼ一定にできると共に、駆動信号の印加時間をさらに短くすることができる。

【００７４】または、前記目標値を少なくとも第１変位素子及び第２変位素子の２つの変位素子についてそれぞれ少なくとも１つ設定し、前記変位検出部は目標値が設定された第１変位素子及び第２変位素子についてそれぞれ変位に関する情報を検出し、前記比較部は第１変位素子及び第２変位素子についてそれら変位素子の情報と目標値とを比較し、前記制御部は前記第１変位素子に関する情報が目標値よりも高くなったときに駆動信号の印加を休止させ、前記第２変位素子に関する情報が目標値以下になったときに駆動信号に印加を開始するように制御することにより、２つの変位素子の変位特性にばらつきがある場合などであっても、アクチュエータの駆動速度などの駆動特性を安定化させることができる。

【００７５】さらに、前記複数の変位素子のうち、少なくとも１つの変位素子を他の変位素子の振動により励振させることにより、アクチュエータの駆動回路及び制御を簡単にすることができる。

【００７６】さらに、前記変位素子の変位に関する情報を、前記変位素子の振幅に関する情報とすることにより、変位素子の変位に関する情報を検出しやすく、かつ検出精度を向上させることができる。

【００７７】特に、前記変位素子を圧電素子とし、前記変位素子の振幅に関する情報として、前記変位素子に流れる電流値を検出することにより、圧電素子の性質を利用してその両端の電圧をモニタすることにより、極めて容易に変位素子の変位に関する情報を得ることができる。

【００７８】さらに、前記変位素子に駆動信号を印加する印加時間及び休止時間を、前記駆動信号の周期と同期させることにより、駆動信号の立ち上がり及び立ち下がりにおいて駆動信号の周期の異なる周期の信号が印加されることが無くなり、アクチュエータの動作をさらに安定させることができる。

【図面の簡単な説明】

【図１】　本発明のアクチュエータの一実施形態であるトラス型アクチュエータの構成を示す図である。

【図２】　上記実施形態において用いられる圧電素子の詳細な構成を示す図である。

【図３】　上記実施形態において一方の圧電素子（駆動側素子）を駆動し、他方の圧電素子（従動側素子）を振動させた場合における各圧電素子に流れる電流値の変化を示す図であり、駆動側素子に駆動信号を印加し始めた直後（起動時）の電流波形を示す。

【図４】　図３と同様にして駆動し、駆動側素子への駆動信号の印加を停止した直後（停止時）の電流波形を示す図である。

【図５】　上記実施形態のアクチュエータにおけるバースト変調駆動の一例を説明するための図である。

【図６】　上記実施形態のアクチュエータにおけるバースト変調駆動の他の一例を説明するための図である。

【図７】　上記実施形態における駆動回路のブロック構成の一例を示す図である。

【図８】　上記実施形態における駆動回路のブロック構成の他の一例を示す図である。

【図９】　図８中のＨブリッジ・ドライバ制御部の詳細な構成を示す図である。

【図１０】　図８中のＨブリッジ・ドライバの詳細な構成を示す図である。

【図１１】　バースト信号と発振器から出力される周波数信号とを同期させた場合及び非同期の場合における各信号波形を示すタイミングチャートである。

【図１２】　発振器からの出力信号が正弦波信号である場合におけるバースト信号と発振器から出力される周波数信号とを同期させるための回路構成を示す図である。

【図１３】　発振器からの出力信号が方形波信号である場合におけるバースト信号と発振器から出力される周波数信号とを同期させるための回路構成を示す図である。

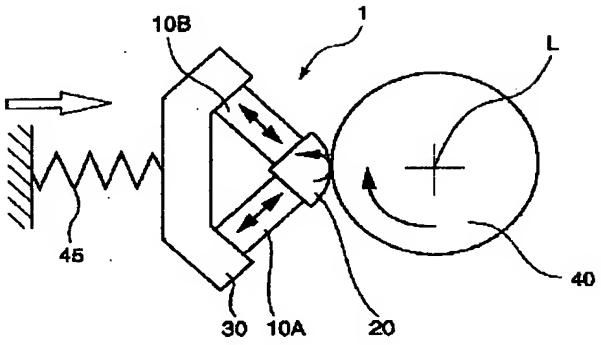
【符号の説明】

１０Ａ：第１圧電素子
１０Ｂ：第２圧電素子
２０　：チップ部材
３０　：ベース部材
４０　：ロータ
５１Ａ：抵抗
５１Ｂ：抵抗
５２Ａ：第１電流検出部
５２Ｂ：第２電流検出部
５３　：位相差検出部
５４　：発振器
５４Ｘ：発振器
５５Ａ：第１スイッチ素子
５５Ｂ：第２スイッチ素子
５５Ｃ：第３スイッチ素子
５５Ｄ：第４スイッチ素子
５６Ａ：第１増幅器
５６Ｂ：第２増幅器

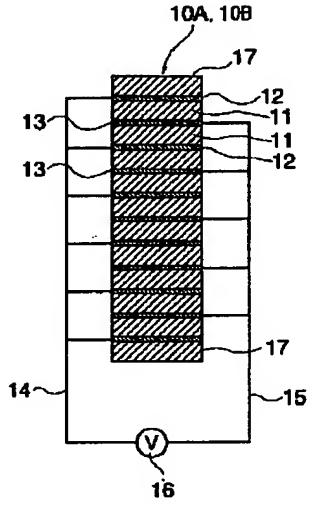
５７Ａ：第１ピーク検出部
５７Ｂ：第２ピーク検出部
５８Ａ：第１電流値比較部
５８Ｂ：第２電流値比較部
６０　：演算処理部
６１　：Ａ／Ｄ変換部
６２　：位相差比較部
６３　：Ｄ／Ａ変換部

６４　：入出力制御部
７０　：モニタ素子切換部
８０　：駆動素子切換部
９０　：ブリッジ・ドライバ制御部
１００Ａ：第１ブリッジ・ドライバ
１００Ｂ：第２ブリッジ・ドライバ
１１０　：ゼロクロスコンパレータ
１１１　：Ｄフリップフロップ

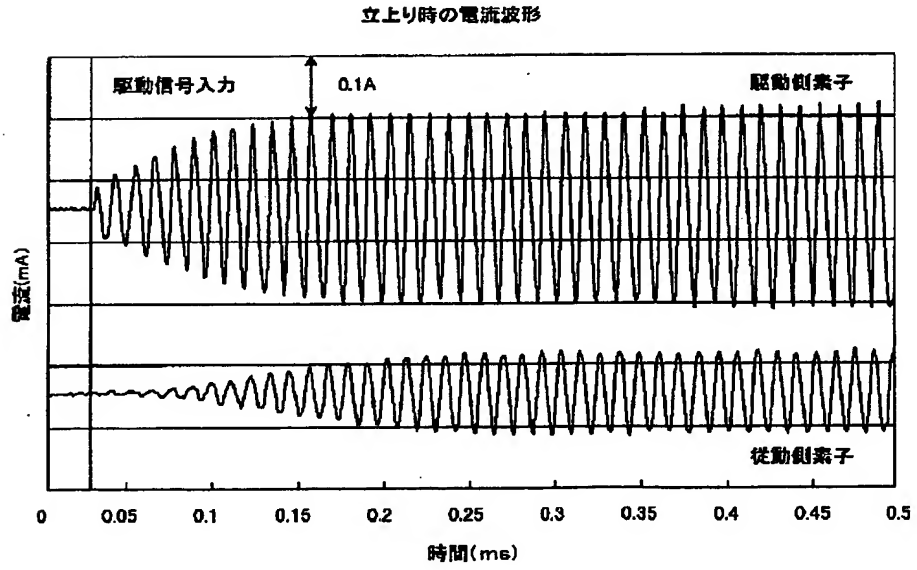
【図１】



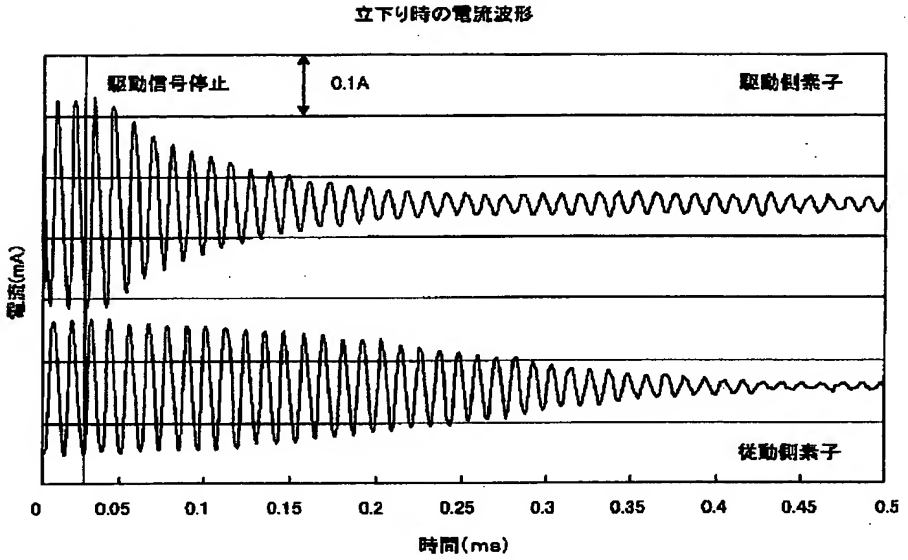
【図２】



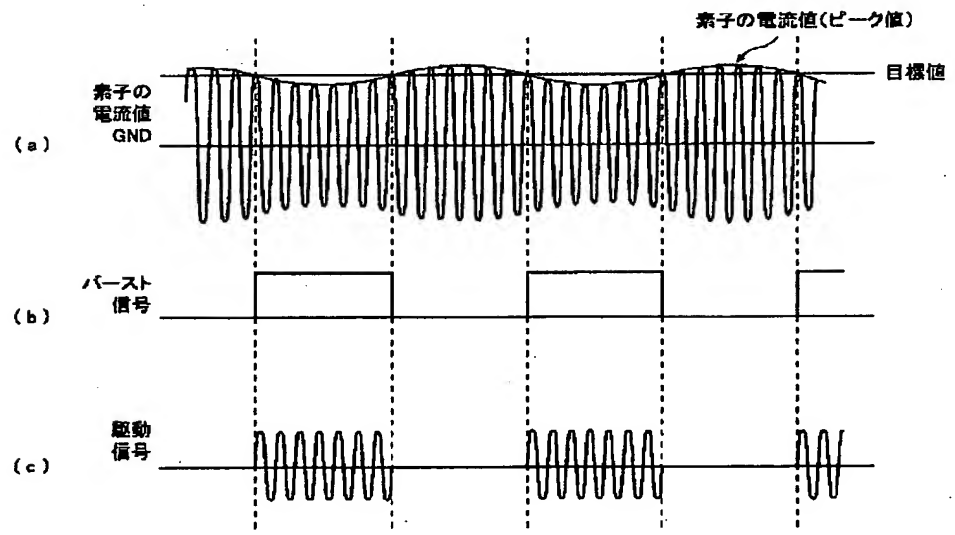
【図３】



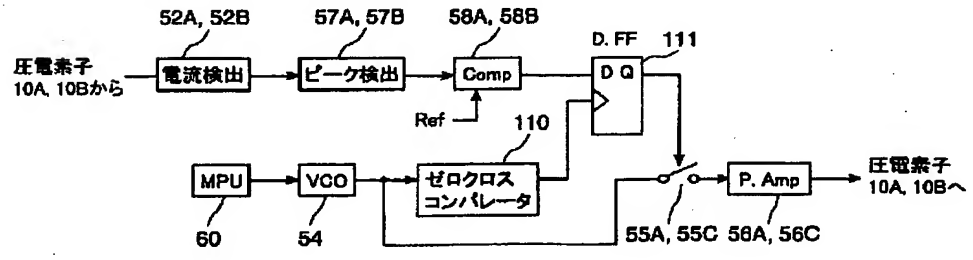
【図４】


立下り時の電流波形
駆動信号停止
0.1A
駆動側素子
従動側素子
電流(mA)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
時間(ms)

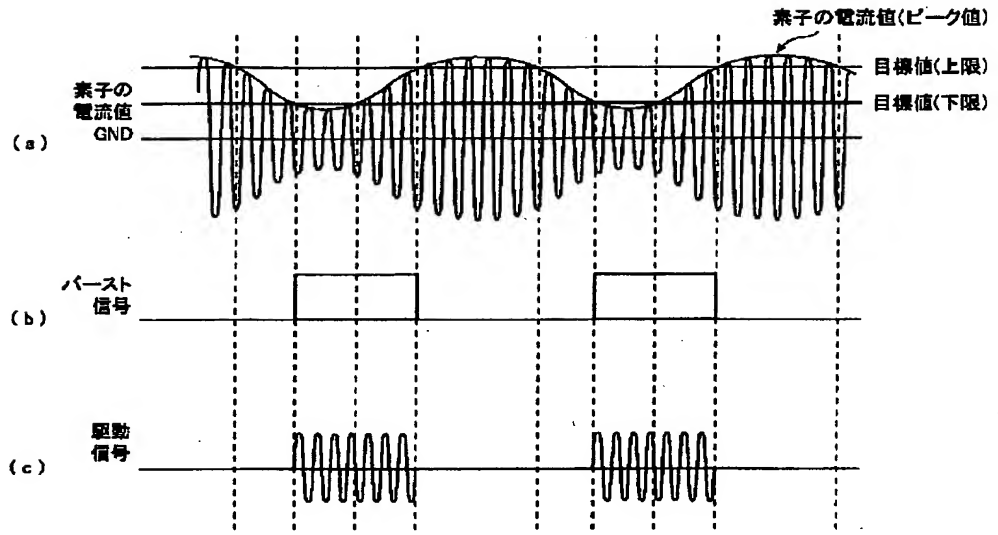
【図５】


素子の電流値(ピーク値)
目標値
素子の
電流値
GND
(a)
バースト
信号
(b)
駆動
信号
(c)

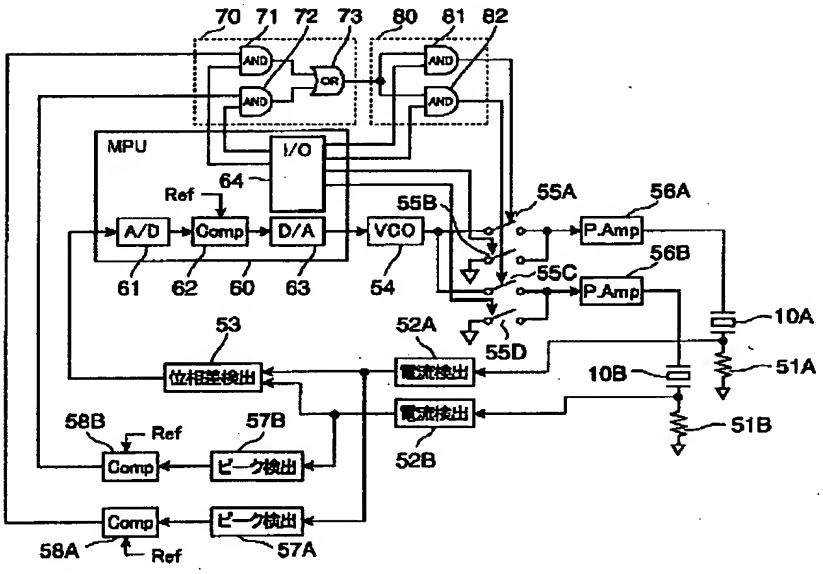
【図１２】


52A, 52B
57A, 57B
58A, 58B
D. FF
111
圧電素子
10A, 10Bから
電流検出
ピーク検出
Comp
D Q
Ref
110
MPU
VCO
ゼロクロス
コンパレータ
P. Amp
圧電素子
10A, 10Bへ
60
54
55A, 55C
56A, 56C

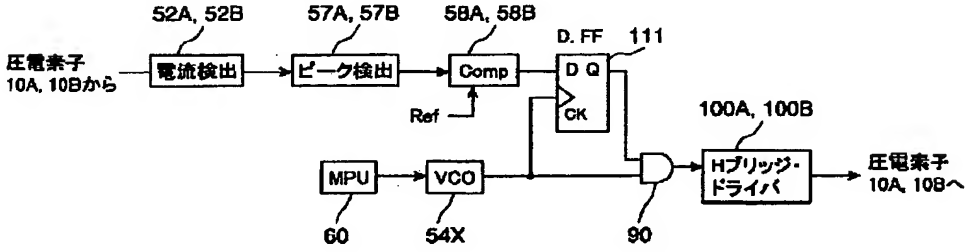
【図６】


素子の電流値(ピーク値)
目標値(上限)
目標値(下限)
素子の
電流値
GND
(a)
バースト
信号
(b)
駆動
信号
(c)

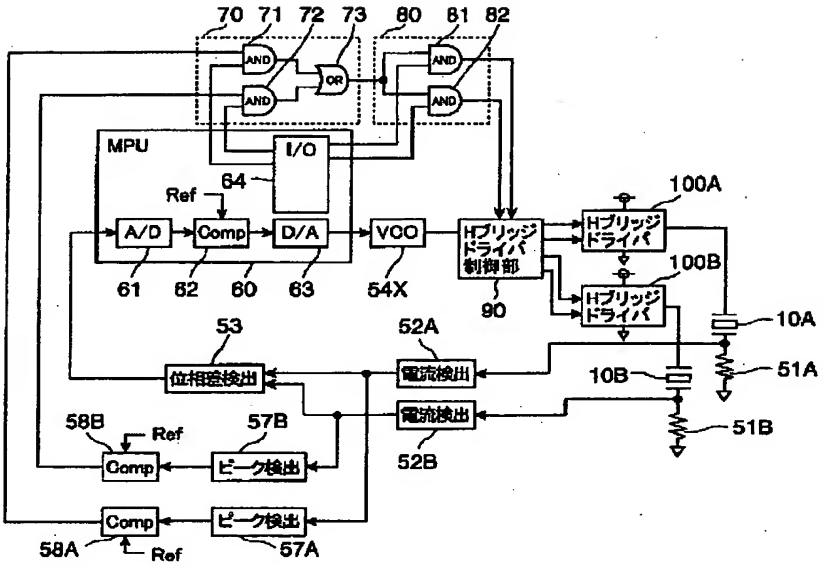
【図７】


70 71 72 73 80 81 82
AND
OR
MPU
I/O
64
Ref
A/D
Comp
D/A
VCO
55A
55B
55C
55D
56A
56B
P.Amp
61 62 60 63 54
10A
10B
51A
51B
53
52A
52B
位相差検出
電流検出
58B
57B
58A
57A
ピーク検出

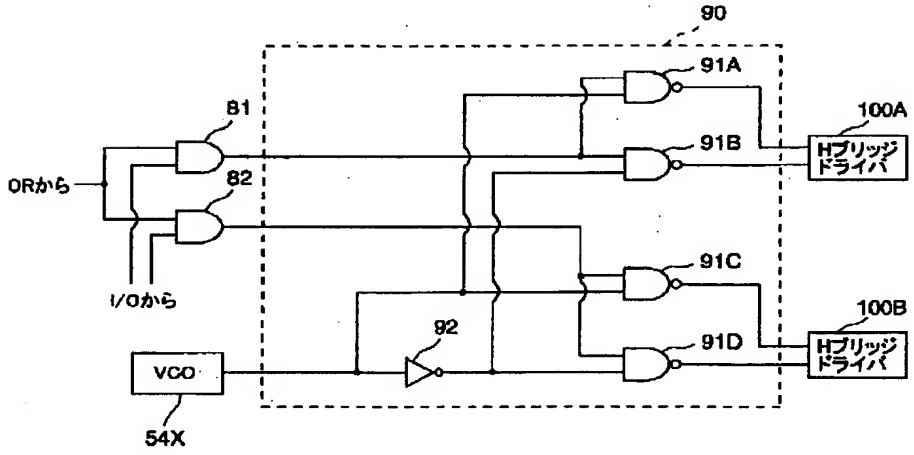
【図１３】


52A, 52B
57A, 57B
58A, 58B
D. FF
111
圧電素子
10A, 10Bから
電流検出
ピーク検出
Comp
Ref
D Q
CK
100A, 100B
MPU
VCO
Hブリッジ・
ドライバ
圧電素子
10A, 10Bへ
60
54X
90

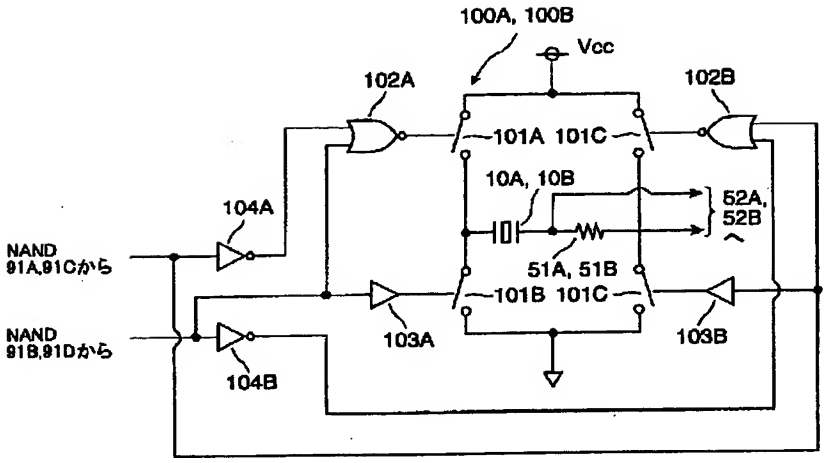
【図８】


70
71
72
73
80
81
82
AND
OR
MPU
I/O
64
Ref
A/D
Comp
D/A
VCO
61
62
60
63
54X
Hブリッジドライバ制御部
90
Hブリッジドライバ
100A
100B
10A
10B
51A
51B
53
位相差検出
52A
電流検出
52B
58B
57B
58A
57A
ピーク検出

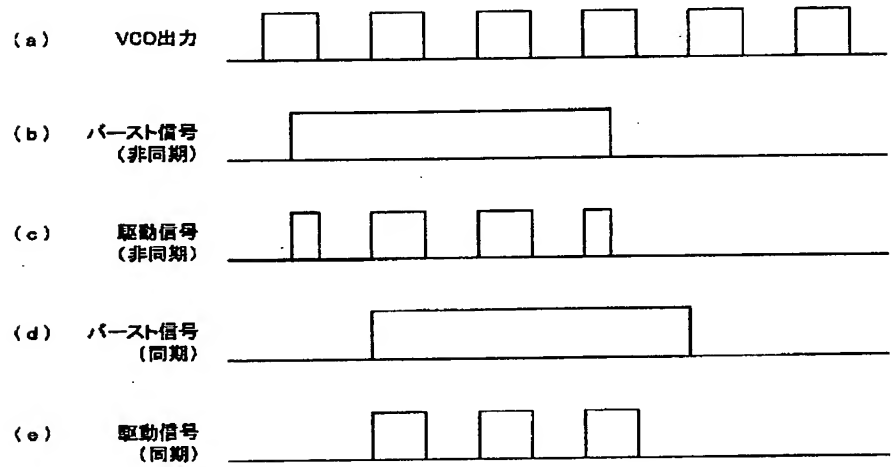
【図９】


90
91A
91B
91C
91D
81
82
ORから
I/Oから
VCO
54X
92
100A
100B
Hブリッジドライバ

【図１０】


100A, 100B
Vcc
102A
102B
101A 101C
10A, 10B
52A,
52B
104A
NAND
91A,91Cから
51A, 51B
101B 101C
NAND
91B,91Dから
103A
103B
104B

【図１１】


(a) VCO出力
(b) バースト信号
(非同期)
(c) 駆動信号
(非同期)
(d) バースト信号
(同期)
(e) 駆動信号
(同期)

PATENT ABSTRACTS OF JAPAN

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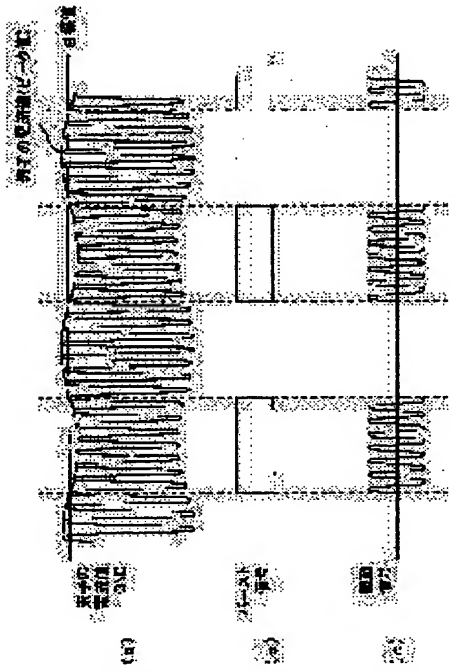
H01L 41/083

(21)Application number : 2001-026367
(22)Date of filing : 02.02.2001

(71)Applicant : MINOLTA CO LTD
(72)Inventor : SHIBATANI KAZUHIRO

(54) ACTUATOR AND ITS DRIVE METHOD

(57)Abstract:
PROBLEM TO BE SOLVED: To realize low-speed drive, the efficient utilization of a battery capacity, and a stable operation of an actuator which moves a driven element in the prescribed direction by applying an AC drive signal to a displacement device, such as a piezoelectric device, etc., to make the displacement device vibrate.
SOLUTION: Information concerning the amplitude of the vibration of the displacement device, for instance a current applied to the piezoelectric device, is monitored. When the peak value of the current reaches a value which is not larger than a target value, the application of a drive signal is started, and when the peak value reaches a value larger than the target value, the application of the driving signal is discontinued.



LEGAL STATUS

[Date of request for examination]

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[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

CLAIMS

[Claim(s)]
[Claim 1] It is the actuator which drives a driven member by making a driven member carry out pressurization contact of the synthetic part. two or more variation rates -- a component -- each -- a variation rate -- the variation rate of a component is compounded -- as -- arranging -- said variation rate -- the variation rate of a component -- The displacement detecting element which detects the information about the variation rate of at least one displacement component, The actuator characterized by providing a comparator [at least one desired value / information / which was detected by said displacement detecting element], and the control section which controls the impression time amount and the quiescent time which impress a driving signal to said displacement component using the comparison result by said comparator.
[Claim 2] Said desired value is an actuator according to claim 1 characterized by starting impression of a driving signal when it was one, impression of a driving signal is stopped when said information becomes higher than said desired value, and said information becomes said below desired value.
[Claim 3] Said desired value is an actuator according to claim 1 characterized by starting impression of a driving signal when it was the 2nd desired value lower than the 1st desired value and the 1st desired value, impression of a driving signal is stopped when said information becomes higher than said 1st desired value, and said information becomes said 2nd less than desired value.
[Claim 4] At least one is set up about a component, respectively. said desired value -- at least -- the 1st variation rate -- a component and the 2nd variation rate -- two variation rates of a component -- A component and the information about a variation rate are detected about a component the 2nd variation rate the 1st variation rate, respectively. said variation rate -- as for the detecting element, desired value was set up -- The information and desired value of a component are compared. said comparator -- the 1st variation rate -- a component and the 2nd variation rate -- a component -- these variation rates -- Said control section is an actuator according to claim 1 characterized by starting impression to a driving signal when impression of a driving signal is stopped when said information about a component becomes higher than desired value the 1st variation rate, and said information about a component becomes below desired value the 2nd variation rate.
[Claim 5] said two or more variation rates -- at least one variation rate among components -- a component -- other variation rates -- an actuator given in either of claims 1-4 characterized by making it excite by vibration of a component.
[Claim 6] The information about the variation rate of said displacement component is an actuator given in either of claims 1-5 characterized by being the information about the amplitude of said displacement component.
[Claim 7] Said displacement component is an actuator according to claim 6 which is a piezoelectric device and is characterized by detecting the current value which flows for said displacement component as information about the amplitude of said displacement component.
[Claim 8] The impression time amount and the quiescent time which impress a driving signal to

said displacement component are an actuator given in either of claims 1-7 characterized by synchronizing with the period of said driving signal.
[Claim 9] It is the drive approach of an actuator of driving a driven member by making a driven member carrying out pressurization contact of the synthetic part. two or more variation rates -- the variation rate of a component -- compounding -- said variation rate -- the variation rate of a component -- The drive approach of the actuator characterized by controlling the impression time amount and the quiescent time which detect the information about the variation rate of at least one displacement component, and impress a driving signal to said displacement component for the detected information using a comparison result as compared with at least one desired value.
[Claim 10] The drive approach of the actuator according to claim 9 which sets said desired value to one and is characterized by starting impression of a driving signal when impression of a driving signal is stopped when said information becomes higher than said desired value, and said information becomes said below desired value.
[Claim 11] The drive approach of the actuator according to claim 9 which makes said desired value the 2nd desired value lower than the 1st desired value and the 1st desired value, and is characterized by starting impression of a driving signal when impression of a driving signal is stopped when said information becomes higher than said 1st desired value, and said information becomes said 2nd less than desired value.
[Claim 12] At least one is set up about a component, respectively. said desired value -- at least -- the 1st variation rate -- a component and the 2nd variation rate -- two variation rates of a component -- A component and the information about a variation rate are detected about a component the 2nd variation rate the 1st variation rate, respectively. desired value was set up -- The information and desired value of a component are compared. the 1st variation rate -- a component and the 2nd variation rate -- a component -- these variation rates -- The drive approach of the actuator according to claim 9 characterized by starting impression to a driving signal when impression of a driving signal is stopped when said information about a component becomes higher than desired value the 1st variation rate, and said information about a component becomes below desired value the 2nd variation rate.
[Claim 13] said two or more variation rates -- at least one variation rate among components -- a driving signal is impressed to a component and it vibrates -- making -- other at least one variation rate -- a component -- said variation rate -- the drive approach of an actuator given in either of claims 9-12 characterized by making it excite by vibration of a component.
[Claim 14] said variation rate -- as the information about the variation rate of a component -- said variation rate -- the drive approach of an actuator given in either of claims 9-13 characterized by detecting the information about the amplitude of a component.
[Claim 15] said variation rate -- as a component -- a piezoelectric device -- using -- said variation rate -- as the information about the amplitude of a component -- said variation rate -- the drive approach of the actuator according to claim 14 characterized by detecting the current value which flows for a component.
[Claim 16] The drive approach of an actuator given in either of claims 9-15 characterized by synchronizing with the period of said driving signal the impression time amount and the quiescent time which impress a driving signal to said displacement component.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the actuator which used displacement components, such as a piezoelectric device, and its drive approach.
[0002]
[Description of the Prior Art] Before, in the actuator (ultrasonic motor) using a piezoelectric device, the burst modulation drive (intermittent drive) is performed for the purpose of the deployment of speed control and cell capacity.

[0003] For example, the technique of controlling the speed by changing the frequency and duty ratio of a burst signal (alternating-voltage driving signal) is shown in JP,7-89748,B. Moreover, after it changes impression time amount and impression time amount reaches a lower limit until it sets up the lower limit of the continuation impression time amount of driver voltage and impression time amount reaches a lower limit, the technique which controls a rate is shown to patent No. 283116 by by changing the quiescent time. Furthermore, the technique of raising the utilization factor of cell capacity is shown to patent No. 3005865 by by changing the due tee ratio of a burst signal.

[0004]

[Problem(s) to be Solved by the Invention] However, now, the technique in which each above-mentioned conventional technique stabilizes the output of the actuator by burst modulation drive about speed control of the actuator by burst modulation drive or a deployment of cell capacity is not known.

[0005] This invention is made in order to solve the trouble of the above-mentioned conventional example, and it aims at offering the actuator which stabilized the output by burst modulation drive, and its drive approach.

[0006]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, the actuator of this invention It is the actuator which drives a driven member by making a driven member carry out pressurization contact of the synthetic part. two or more variation rates -- a component -- each -- a variation rate -- the variation rate of a component is compounded -- as -- arranging -- said variation rate -- the variation rate of a component -- The displacement detecting element which detects the information about the variation rate of at least one displacement component, It is characterized by providing a comparator [at least one desired value / information / which was detected by said displacement detecting element], and the control section which controls the impression time amount and the quiescent time which impress a driving signal to said displacement component using the comparison result by said comparator.

[0007] In the above-mentioned configuration, said desired value is one, and when impression of a driving signal is stopped when said information becomes higher than said desired value, and said information becomes said below desired value, it is desirable to start impression of a driving signal.

[0008] Moreover, said desired value is the 2nd desired value lower than the 1st desired value and the 1st desired value, and when impression of a driving signal is stopped when said information becomes higher than said 1st desired value, and said information becomes said 2nd less than desired value, it is desirable [desired value] to start impression of a driving signal.

[0009] At least one is set up about a component, respectively. furthermore, said desired value -- at least -- the 1st variation rate -- a component and the 2nd variation rate -- two variation rates of a component -- A component and the information about a variation rate are detected about a component the 2nd variation rate the 1st variation rate, respectively. said variation rate -- as for the detecting element, desired value was set up -- The information and desired value of a component are compared. said comparator -- the 1st variation rate -- a component and the 2nd variation rate -- a component -- these variation rates -- When impression of a driving signal is stopped when said information about a component becomes higher than desired value the 1st variation rate, and said information about a component becomes below desired value the 2nd variation rate, as for said control section, it is desirable to start impression to a driving signal.

[0010] Furthermore, it is desirable to excite at least one displacement component by vibration of other displacement components among said two or more displacement components.

[0011] Furthermore, as for the information about the variation rate of said displacement component, it is desirable that it is the information about the amplitude of said displacement component.

[0012] Furthermore, said displacement component is a piezoelectric device and it is desirable to detect the current value which flows for said displacement component as information about the amplitude of said displacement component.

[0013] Furthermore, as for the impression time amount and the quiescent time which impress a

driving signal to said displacement component, synchronizing with the period of said driving signal is desirable.
[0014] On the other hand, the drive approach of the actuator of this invention It is the drive approach of an actuator of driving a driven member by making a driven member carrying out pressurization contact of the synthetic part. two or more variation rates -- the variation rate of a component -- compounding -- said variation rate -- the variation rate of a component -- It is characterized by controlling the impression time amount and the quiescent time which detect the information about the variation rate of at least one displacement component, and impress a driving signal to said displacement component for the detected information using a comparison result as compared with at least one desired value.
[0015] In the above-mentioned approach, when said desired value was set to one, impression of a driving signal is stopped when said information becomes higher than said desired value, and said information becomes said below desired value, it is desirable to start impression of a driving signal.
[0016] Moreover, when said desired value was made into the 2nd desired value lower than the 1st desired value and the 1st desired value, impression of a driving signal is stopped when said information becomes higher than said 1st desired value, and said information becomes said 2nd less than desired value, it is desirable to start impression of a driving signal.
[0017] At least one is set up about a component, respectively. furthermore, said desired value -- at least -- the 1st variation rate -- a component and the 2nd variation rate -- two variation rates of a component -- A component and the information about a variation rate are detected about a component the 2nd variation rate the 1st variation rate, respectively. desired value was set up -- The information and desired value of a component are compared. the 1st variation rate -- a component and the 2nd variation rate -- a component -- these variation rates -- When impression of a driving signal is stopped when said information about a component becomes higher than desired value the 1st variation rate, and said information about a component becomes below desired value the 2nd variation rate, it is desirable to start impression to a driving signal.
[0018] furthermore, said two or more variation rates -- at least one variation rate among components -- a driving signal is impressed to a component and it vibrates -- making -- other at least one variation rate -- a component -- said variation rate -- it is desirable to make it excite by vibration of a component.
[0019] Furthermore, it is desirable to detect the information about the amplitude of said displacement component as information about the variation rate of said displacement component.
[0020] Furthermore, it is desirable to detect the current value which flows for said displacement component as information about the amplitude of said displacement component, using a piezoelectric device as said displacement component.
[0021] Furthermore, it is desirable to synchronize with the period of said driving signal the impression time amount and the quiescent time which impress a driving signal to said displacement component.
[0022]
[Embodiment of the Invention] The actuator concerning 1 operation gestalt of this invention is explained. the truss which is an actuator concerning this operation gestalt -- the configuration of a mold actuator is shown in drawing 1 .
[0023] 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B of two laminating molds which have been arranged so that a drive unit may make a predetermined include angle (for example, 90 degrees) mutually as shown in drawing 1 , The chip member 20 joined to the crossover side edge section of 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B by adhesives etc. (driving member), The base member 30 to which it is fixed to by adhesives etc. and the end face section of 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B holds 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B, It consists of pressurization members (elastic bodies, such as coiled spring and flat spring) 45 which generate the welding pressure for making the chip member 20 contact the front face of Rota 40.
[0024] The detail of 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B is shown in drawing 2 . In addition, both are the same configurations substantially. Each piezoelectric

devices 10A and 10B carry out the laminating of two or more ceramic sheet metal 11 and electrodes 12 and 13 in which piezo-electric properties, such as PZT (titanic-acid lead zirconate), are shown, respectively by turns, and each ceramic sheet metal 11 and electrodes 12 and 13 are being fixed by adhesives etc. Each electrode groups 12 and 13 arranged alternately are connected to the drive power source 16 through signal lines 14 and 15, respectively. When a predetermined electrical potential difference is impressed among signal lines 14 and 15, in each ceramic sheet metal 11 inserted into electrodes 12 and 13, electric field occur in the direction of a laminating, and the electric field are the alternately same directions. therefore, as for each ceramic sheet metal 11, the direction of polarization becomes the same alternately (the direction of polarization of two adjacent ceramic sheet metal 11 becomes reverse) -- the laminating is carried out like. In addition, the protective layer 17 is formed in the both ends of each piezoelectric devices 10A and 10B.

[0025] If the driver voltage of a direct current is impressed among each electrodes 12 and 13 according to the drive power source 16, elongation or shrinkage, and each piezoelectric devices 10A and 10B expand in this direction and contract [all ceramic sheet metal 11] as a whole. Electric field are small and it can be considered that the variation rate of the electric field generated among each electrodes 12 and 13 and each piezoelectric devices 10A and 10B is almost linear relation in the field which can disregard the hysteresis like browning.

[0026] On the other hand, if the driver voltage (AC signal) of an alternating current is impressed among each electrodes 12 and 13 according to the drive power source 16, according to the electric field, each ceramic sheet metal 11 will repeat telescopic motion in this direction, and each piezoelectric devices 10A and 10B will repeat telescopic motion as a whole. The resonance frequency of the proper determined by the structure and electrical characteristics exists in each piezoelectric devices 10A and 10B. If the frequency of the driver voltage of an alternating current is in agreement with the resonance frequency of each piezoelectric devices 10A and 10B, an impedance will fall and the variation rate of each piezoelectric devices 10A and 10B will increase. Since the variation rate is small, in order to drive on a low electrical potential difference to that dimension, as for each piezoelectric devices 10A and 10B, it is desirable to use these resonance phenomena.

[0027] The tungsten which was stabilized, and high coefficient of friction was obtained as an ingredient of the chip member 20, and was excellent in abrasion resistance is desirable. As an ingredient of the base member 30, manufacture is easy and the stainless steel excellent in reinforcement etc. is desirable. Moreover, as adhesives, epoxy system resin excellent in adhesive strength and reinforcement etc. is desirable.

[0028] Whether 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B are driven with the AC signal which has phase contrast, respectively, and by crawling again and driving one [a gap or] piezoelectric-device 10A or 10B, it can drive so that the chip member 20 may draw an elliptical orbit or a circular orbit. If this chip member 20 is forced on the cylinder side of Rota 40 pivotable around the predetermined shaft L, it will become possible to change ellipse movement or the circular motion of the chip member 20 into rotation of Rota 40. Or it becomes possible by forcing the chip member 20 on the flat-surface section of a cylindrical member (not shown) to change ellipse movement or the circular motion of the chip member 20 into the rectilinear motion of a cylindrical member. As an ingredient of Rota 40, lightweight metals, such as aluminum, are desirable, and in order to prevent wear by friction with the chip member 20, it is desirable to perform tufftriding, alumite processing, etc. to a front face.

[0029] a truss as shown in drawing 1 -- as the drive approach of a mold actuator How to impress the driving signal which has predetermined phase contrast, respectively to two piezoelectric devices 10A and 10B, and to drive two piezoelectric devices 10A and 10B to coincidence, One of piezoelectric-device (driving-side component) 10A or 10B are driven, and the drive approach of transmitting vibration to which vibration in which the phase was behind [piezoelectric-device (follower side component) 10B or 10A of another side], or a phase progressed can be considered. The latter drive approach is adopted in the actuator of this operation gestalt.

[0030] When driving only one of piezoelectric-device 10A or 10B, the phase contrast of vibration of piezoelectric-device 10B used as vibration and the passive element of piezoelectric-device 10A

used as a driver element or 10B or 10A changes with the frequencies of a driving signal. Moreover, the configuration of the locus of the chip member 20 prepared in the intersection of one piezoelectric devices 10A and 10B changes with the phase contrast of vibration of these two piezoelectric devices 10A and 10B according to the formula (formula of Lissajous) of ellipse vibration.

[0031] If it will expand and contract in the direction of electric field, and an electrical potential difference is impressed to a piezoelectric device and tensile force or compressive force will be applied in the predetermined direction to a piezoelectric device as everyone knows, an electrical potential difference will be generated in the direction. Therefore, the vibrational state of a driving-side component and a follower side component can be known by carrying out the monitor of the current which flows with the electrical potential difference generated for the current which flows for a driving-side component, and a follower side component.

[0032] Next, an alternating-voltage (sine wave) driving signal is inputted and driven to one piezoelectric-device (driving-side component) 10A or 10B, and the current value change which flows to each piezoelectric devices 10A and 10B at the time of vibrating piezoelectric-device (follower side component) 10B or 10A of another side is shown in drawing 3 and drawing 4 . Drawing 3 shows the current wave form immediately after beginning to impress a driving signal to a driving-side component (at the time of starting), and drawing 4 shows the current wave form immediately after stopping impression of the driving signal to a driving-side component (at the time of a halt). These current wave forms are detected using the resistance connected to the serial, respectively to each piezoelectric devices 10A and 10B.

[0033] A standup until a driving-side component and a follower side component reach the predetermined amplitude at the time of starting takes time amount so that drawing 3 may show. Moreover, although a driving-side component starts vibration comparatively immediately from impression initiation of a driving signal, time amount is taken for a follower side component to start vibration for a while. Moreover, falling until it decreases a driving-side component and a follower side component to the predetermined amplitude similarly at the time of a halt takes time amount so that drawing 4 may show. Moreover, even if a follower side component has late falling compared with a driving-side component and a driving-side component decreases it mostly, it is still vibrating with the predetermined amplitude. Thus, when driving only one piezoelectric device, in order to use resonance phenomena, the standup of vibration of each piezoelectric device takes time amount, and after a halt of a driving signal carries out fixed time amount continuation of the vibration of each piezoelectric device.

[0034] Next, the burst modulation drive in the actuator of this operation gestalt is explained, referring to drawing 5 and drawing 6 . In each drawing, (a) expresses the driving signal with which the current value which flows to piezoelectric-device 10A or 10B by which a monitor is carried out, and (b) are impressed to a burst signal, and (c) is actually impressed to a piezoelectric device, respectively. In addition, the piezoelectric devices by which a monitor is carried out may be any of a driving-side component and a follower side component.

[0035] Even if a burst modulation drive stops the driving signal impressed to a driving-side component, it uses the phenomenon which vibration of fixed time amount each piezoelectric device maintains. The example of a drive shown in drawing 5 is the case where only one desired value of control is set up, and when the driving signal was impressed continuously, the predetermined value was exceeded, impression of a driving signal is stopped and a current value turns into below a predetermined value further until the current value which flows to piezoelectric-device 10A or 10B becomes higher than a predetermined value, it resumes impression of a driving signal. In the example of a drive shown in drawing 5 , only while the burst signal between below desired value is outputted for the peak value of the alternating current value which flows to the piezoelectric device by which a monitor is carried out and the burst signal is outputted, a driving signal is impressed to a driving-side component.

[0036] Moreover, when impression of a driving signal is stopped when the driving signal was continuously impressed until the current value which is the case where the example of the drive shown in drawing 6 sets up two desired value of control, and flows to piezoelectric-device 10A or 10B became higher than the 1st predetermined value, and the 1st predetermined value was

exceeded, and it becomes below the 2nd predetermined value with a current value still smaller than the 1st predetermined value, impression of a driving signal is resumed. In the example of a drive shown in drawing 6 , only while a burst signal is outputted and the burst signal is outputted until it exceeds the 1st desired value from the time of the peak value of the alternating current value which flows to the piezoelectric device by which a monitor is carried out turning into the 2nd less than desired value, a driving signal is impressed to a driving-side component. Although the actuator is vibrating continuously seemingly by repeating these actuation, a driving signal is not supplied intermittently and the low-speed drive of an actuator and the deployment of cell capacity of it are attained. Furthermore, since it is controlled so that the peak value of the current which flows to the piezoelectric device by which a monitor is carried out becomes fixed within the limits, a rate, torque, etc. of a driven member by the actuator can be stabilized.

[0037] Next, an example of the block configuration of the drive circuit in this operation gestalt is shown in drawing 7 . In the example shown in drawing 7 , a sinusoidal-voltage signal is used as a driving signal impressed to piezoelectric-device 10A or 10B.

[0038] In order to detect the current which flows to each piezoelectric devices 10A and 10B, respectively, series connection of the resistance 51A and 51B is carried out to 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B. The terminal voltage of each resistance 51A and 51B is detected as a sinusoidal current wave as inputted into 1st current detecting-element 52A and 2nd current detecting-element 52B, respectively, for example, shown in drawing 3 and drawing 4 . Each current detecting elements 52A and 52B consist of amplifier, zero cross comma RETA, etc., respectively, and after they shape a sinusoidal current wave in waveform to a square wave, they input a square wave signal into the phase contrast detecting element 53. The phase contrast detecting element 53 consists of an exclusive OR circuit, a low pass filter, etc., and detects the phase contrast of two inputted signals.

[0039] The phase contrast signal of the analog obtained by the phase contrast detecting element 53 is inputted into the A/D-conversion section 61 of the data-processing section (MPU) 60, and after being digital-signal-ized, it is compared with target phase contrast (Ref) by the phase contrast comparator (Comp) 62. The comparison result (it is [target phase contrast and] actually a difference with phase contrast) by the phase contrast comparator 62 is inputted into the D/A transducer 63, and after being digital-signal-ized, it is inputted into a voltage controlled oscillator (VCO) 54. In addition, although I/O control unit (I/O) 64 is formed in the data-processing section 60, the function is mentioned later.

[0040] An oscillator 54 adjusts the oscillation frequency according to the output from the data-processing section 60. The sinusoidal signal with which the frequency was adjusted is inputted into 1st amplifier 56A and 2nd amplifier 56B through the 1st - the 4th switching device 55A-55D, and is amplified by the predetermined amplitude. Each switches 55A-55D shall be turned on if the signal which consists of components, such as a transistor, respectively, for example, is equivalent to high level or "1" is inputted, and it shall be constituted so that it may turn off, if the signal equivalent to a low level or "0" is inputted. In addition, in the following explanation, it considers as a "high-level signal" and a "low-level signal" for convenience.

[0041] The driving signal which the driving signal amplified by 1st amplifier 56A was impressed to 1st piezoelectric-device 10A, and was amplified by 2nd amplifier 56B is impressed to 2nd piezoelectric-device 10B. Thus, it becomes possible by detecting the actual vibrational state of 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B using a current value etc., and carrying out feedback control of the frequency of a driving signal so that it may be in agreement with target phase contrast in the phase contrast of those vibration to make the configuration which asks for the locus of the chip member 20 resemble.

[0042] In addition, switching devices 55A-55D are used in order to control impression initiation and a halt of the driving signal in the case of the change of any [a driving-side component and] to make into a follower side component for any between 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B, and burst modulation control. Moreover, since only one of piezoelectric-device 10A or 10B are driven with this operation gestalt and the piezoelectric device of another side is made to follow, there is nothing of 1st piezoelectric-device 10A and 2nd

piezoelectric-device 10B for which switching devices 55A-55D are controlled so that a driving signal is both impressed to coincidence.

[0043] On the other hand, the output of 1st current detecting-element 52A is inputted into 1st peak detecting-element 57A, and the output of 2nd current detecting-element 52B is inputted into 2nd peak detecting-element 57B. Each peak detecting elements 57A and 57B detect those peaks from a sinusoidal signal as shown in drawing 5 (a) or drawing 6 (a) detected by each current detecting elements 52A and 52B. The peak value signal detected by each peak detecting elements 57A and 57B is inputted into 1st current value comparator 58A and 2nd current value comparator 58B, respectively, and is compared with desired value. As an example, each current value comparators 58A and 58B output a low-level signal, when the peak value of the detected current is higher than desired value (it is either of two desired value depending on the case), and in below desired value, they output a high-level signal. Each current value comparators 58A and 58B compare with predetermined desired value the peak value of the current which always flows to each piezoelectric devices 10A and 10B, and output it to the monitor component change section 70.

[0044] The monitor component change-over section 70 consists of 1st AND circuit 71, 2nd AND circuit 72, and OR circuit 73, the output signal from 1st current value comparator 58A is inputted into 1st AND circuit 71, and the output signal from 2nd current value comparator 58B is inputted into 2nd AND circuit 72. Moreover, 1st AND circuit 71 and 2nd AND circuit 72 are connected to I/O control unit 64 of the data-processing section 60, respectively. I/O control unit 64 outputs a high-level signal to AND circuit 71 connected to the side used as a monitor component among 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B, or 72, and outputs a low-level signal to another side. For example, when using 1st piezoelectric-device 10A as a monitor component, I/O control unit 64 outputs a high-level signal to 1st AND circuit 71, and outputs a low-level signal to 2nd piezoelectric-device 10B. Therefore, even if a high-level signal is outputted from 2nd current value comparator 58B, 2nd AND circuit 72 is not turned on but a low-level signal is outputted from 2nd AND circuit 72. On the other hand, if the peak value of the current which flows to 1st piezoelectric-device 10A turns into below desired value, since a high-level signal will be outputted from 1st current value comparator 58A, 1st AND circuit 71 turns on, and a high-level signal is outputted from 1st AND circuit 71. Since a high-level signal is inputted into OR circuit 73 from 1st AND circuit 71 and a low-level signal is inputted into it from 2nd AND circuit 72, respectively, from OR circuit 73, a high-level signal is outputted to the driver element change-over section 80.

[0045] The driver element change-over section 80 consists of 3rd AND circuit 81 and 4th AND circuit 82, and the output from OR circuit 73 is inputted into 3rd AND circuit 81 and 4th AND circuit 82. Moreover, 3rd AND circuit 81 and 4th AND circuit 82 are connected to I/O control unit 64 of the data-processing section 60, respectively. I/O control unit 64 outputs a high-level signal to AND circuit 81 connected to the side used as a driving-side component among 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B, or 82, and outputs a low-level signal to another side. For example, when using 1st piezoelectric-device 10A as a driving-side component, I/O control unit 64 outputs a high-level signal to 3rd AND circuit 81, and outputs a low-level signal to 2nd piezoelectric-device 10B. Therefore, even if a high-level signal is outputted from OR circuit 73, 4th AND circuit 82 is not turned on but a low-level signal is outputted from 4th AND circuit 82. On the other hand, if a high-level signal is outputted from OR circuit 73, 3rd AND circuit 81 will turn on and a high-level signal will be outputted from 3rd AND circuit 81.

[0046] 3rd AND circuit 81 is connected to 1st switching device 55A prepared between an oscillator 54 and 1st amplifier 56A, and 4th AND circuit 82 is connected to 3rd switching device 55C prepared between an oscillator 54 and 2nd amplifier 56B. Moreover, I/O control unit 64 is connected to 2nd switching device 55B and 4th switching device 55D which were prepared between a ground, 1st amplifier 56A, and 2nd amplifier 56B.

[0047] If a high-level signal is outputted from 3rd AND circuit 81, 1st switching device 55A turns on, and the sinusoidal signal outputted from an oscillator 54 will be inputted into 1st amplifier 56A, will be amplified by the predetermined amplitude, and will be impressed to 1st piezoelectric-device 10A as a driving signal. If a low-level signal is outputted from 3rd AND

circuit 81, 1st switching device 55A will turn off, the sinusoidal signal outputted from an oscillator 54 will no longer be inputted into 1st amplifier 56A, and impression of the driving signal to 1st piezoelectric-device 10A will be stopped. In addition, 1st switching device 55A and 3rd switching device 55C do not turn on in coincidence from the configuration of the above-mentioned driver element change-over section 80. Moreover, when 1st piezoelectric-device 10A or 2nd piezoelectric-device 10B is used as a follower side component, respectively, 2nd switching device 55B and 4th switching device 55D are used in order to discharge a charge collected on the follower side component.

[0048] While being able to carry out feedback control of the frequency of a driving signal, using 1st piezoelectric-device 10A or 2nd piezoelectric-device 10B as a driving-side component, and driving another side as a follower side component by such circuitry so that the chip member 20 may draw a predetermined locus, the burst modulation drive which controls impression initiation and a halt of a driving signal can be performed carrying out the monitor of the current which flows for one of components.

[0049] In addition, although the above-mentioned explanation compared this value and desired value using the forward peak value of alternating current as a current value of piezoelectric-device 10A which carries out a monitor, or 10B, it is not limited to this, and if it is the information about amplitude of a displacement component (piezoelectric device), such as actual value, negative peak value, etc. of a current, it is good anything. Furthermore, it constituted so that desired value might be set to either a driving-side component or a follower side component and the monitor of the information about the amplitude of the component might be carried out, but it is not limited to this and one or two desired value may be set to both a driving-side component and a follower side component, respectively, and you may constitute so that the monitor of both a driving-side component and the follower side component may be carried out. A burst signal may be started in that case using the information about the amplitude of a driving-side component, and you may constitute so that a burst signal may be brought down using the information about the amplitude of a follower side component. In that case, I/O control unit 64 should just change by turns the signal inputted into 1st AND circuit 71 and 2nd AND circuit 72 of the monitor component change-over section 70. These application is the same also in the following modifications.

[0050] Next, the block configuration of the modification of the drive circuit in this operation gestalt is shown in drawing 8 . Moreover, the detail of H bridge driver control section in drawing 8 is shown in drawing 9 , and the detail of H bridge driver is shown in drawing 10 . In the modification shown in drawing 8 - drawing 10 , a square wave voltage signal is used as a driving signal impressed to piezoelectric-device 10A or 10B. In addition, since the component which attached the same sign as the circuit shown in above-mentioned drawing 7 is substantially the same, the explanation is omitted.

[0051] Among drawing 8 , voltage controlled oscillator 54X oscillates a square wave signal, and is inputted into H bridge driver control section 90. Moreover, the output from 3rd AND circuit 81 and 4th AND circuit 82 of the driver element change-over section 80 is also inputted into H bridge driver control section 90. H bridge driver control section 90 controls 2ndH bridge driver 100B connected to 1stH bridge driver 100A and 2nd piezoelectric-device 10B which were connected to 1st piezoelectric-device 10A, respectively.

[0052] As shown in drawing 9 , H bridge driver control section 90 consists of the 1st - 4th NAND circuit 91A-91D, and an inverter 92. The square wave signal from oscillator 54X is inputted into the 2NAND-circuit91B and 4th NAND-circuit 91D, after a direct input is carried out to the 1NAND-circuit91A and 3rd NAND-circuit 91C and it is reversed with an inverter 92. On the other hand, the output of 3rd AND circuit 81 is inputted into the 1NAND-circuit91A and 2nd NAND-circuit 91B, and the output of 4th AND circuit 82 is inputted into 3rd NAND-circuit 91C and 4th NAND-circuit 91D.

[0053] Therefore, high-level [the square wave signal from oscillator 54X], when 1st piezoelectric-device 10A is chosen, for example as a driving-side component, when the output from 3rd AND circuit 81 is high-level, a high-level signal is inputted into 1stH bridge driver 100A for a low-level signal from 2nd NAND circuit 92 from 1st NAND circuit 91, respectively. On the

contrary, the square wave signal from oscillator 54X is a low level, and when the output from 3rd AND circuit 81 is high-level, a low-level signal is inputted into 1stH bridge driver 100A for a high-level signal from 2nd NAND circuit 92 from 1st NAND circuit 91, respectively. On the other hand, since the signal from 4th AND circuit 82 is a low level, from 3rd NAND-circuit 91C and 4th NAND-circuit 91D, a high-level signal is outputted, respectively. It is also the same as when 2nd piezoelectric-device 10B is chosen as a driving-side component.

[0054] Next, the configuration of H bridge drivers 100A and 100B is shown in drawing 10 . The 5th which constitutes the bridge circuit for controlling initiation and a halt of impression of driver voltage Vcc to the series circuit of 1st piezoelectric-device 10A and resistance 51A, or the series circuit of 2nd piezoelectric-device 10B and resistance 51B - the 8th switching device 101A-101D, The 1NOR-circuit102A connected to 5th switching device 101A, the 2NOR-circuit102B connected to 7th switching device 101C, It consists of buffers 103A and 103B connected to 6th switching device 101B and 8th switching device 101D, respectively, the 2nd and 3rd inverters 104A and 104B connected to each NOR circuits 102A and 102B. In addition, Buffers 103A and 103B are used in order to adjust the impedance of the switching elements 101B and 101D which consisted of transistors etc.

[0055] While the output signal from the 1NAND-circuit91A or 3rd NAND-circuit 91C is inputted into 1st NOR-circuit 102A through 2nd inverter 104A, the direct input of it is carried out to 2nd NOR-circuit 102B. On the other hand, the output signal from the 2NAND-circuit91B or 4th NAND-circuit 91D is inputted into the 2NOR-circuit102B and buffer 103B through 3rd inverter 104B while it is directly inputted into the 1NOR-circuit102A and buffer 103A.

[0056] The signal from the 1NAND-circuit91A or 3rd NAND-circuit 91C shows the operating state of ON / OFF, and piezoelectric-device 10A of the 5th [signal / from high level, low-level, and the 2NAND-circuit91B or 4th NAND-circuit 91D] according to the combination of high level or a low level - the 8th switching device, or 10B in the following table 1. In addition, signal"X" expresses the signal from the 1NAND-circuit91A or 3rd NAND-circuit 91C among Table 1, and signal"Y" expresses the signal from the 2NAND-circuit91B or 4th NAND-circuit 91D. Moreover, "H" and "L" express that the level of a signal is high level and a low level, respectively, and SW5-SW8 express the 5th - the 8th switching device, respectively. Furthermore, "drive mode" expresses the condition of piezoelectric-device 10A or 10B.

[0057]

[Table 1]

信 号		スイッチ素子				駆動モード
X	Y	SW5	SW6	SW7	SW8	
L	L	OFF	OFF	OFF	OFF	停止
L	H	ON	OFF	OFF	ON	駆動側素子(正方向充電)
H	L	OFF	ON	ON	OFF	駆動側素子(逆方向充電)
H	H	OFF	ON	OFF	ON	従動側素子又は停止

[0058] In the above-mentioned modification, amplify the signal oscillated by oscillator 54X, consider as a driving signal, and this is not impressed to piezoelectric-device 10A or 10B. Since it uses as a timing signal for impressing the driver voltage Vcc to which the signal from the above-mentioned oscillator 54X is supplied by H bridge driver 100A or 100B to piezoelectric-device 10A or 10B The cycle signal by oscillator 54X can be dealt with in digital one, and the configuration of a drive circuit -- amplifier becomes unnecessary -- can be simplified.

[0059] In addition, although the driving signal impressed to piezoelectric-device 10A or 10B is a square wave, since the frequency is near the resonance frequency of each piezoelectric devices 10A and 10B, vibration of each piezoelectric devices 10A and 10B becomes in sine wave. Therefore, although the current wave form where it flows to each piezoelectric devices 10A and 10B also becomes in sine wave, the current which flows for a driving-side component is

overlapped on the noise resulting from the rush current by the driving signal. Therefore, it is desirable to carry out low pass filter processing of the current wave form detected by the current detecting elements 52A and 52B.

[0060] Next, it explains the synchronization with the signalling frequency outputted from a burst signal, an oscillator 54, or 54X, and asynchronous. Drawing 11 is a synchronization and a timing chart in asynchronous, in the signalling frequency (square wave) from oscillator (VCO) 54X, and (b), the driving signal in asynchronous and (d) express the burst signal in a synchronization, and, as for (e), the burst signal in asynchronous and (c) express [(a)] each wave of the driving signal in a synchronization.

[0061] In each drive circuit shown in drawing 7 and drawing 8 , ** it does not take the synchronization of the signalling frequency outputted from a burst signal, an oscillator 54, or 54X, it is asynchronous and is driving. Although the sinusoidal signal or square wave signal of predetermined frequency is continuously outputted from an oscillator 54 or 54X, only while the burst signal is outputted, it consists of each above-mentioned drive circuit so that a driving signal may not be impressed to piezoelectric-device 10A or 10B. If it returns, the driving signal impressed to piezoelectric-device 10A or 10B will serve as a wave which took AND of the signalling frequency of (a), and the burst signal of (b) as shown in drawing 11 (c). Since the signalling frequency outputted from a burst signal, an oscillator 54, or 54X does not synchronize, a different wave-like driving signal from the signalling frequency outputted from the oscillator 54 as shown in (c), or 54X is impressed to a piezoelectric device. In that case, when a signal with a short period like the both ends of (c) is intermingled in a driving signal, there is a possibility that vibration of piezoelectric-device 10A or 10B may become instability a little.

[0062] On the other hand, if the signalling frequency outputted from a burst signal, an oscillator 54, or 54X is synchronized as shown in (d), the wave-like driving signal with the same signalling frequency outputted from the oscillator 54 as shown in (e), or 54X will be impressed to a piezoelectric device. Consequently, vibration of piezoelectric-device 10A or 10B can be stabilized more.

[0063] The circuitry for synchronizing the signalling frequency outputted from a burst signal, an oscillator 54, or 54X is shown in drawing 12 and drawing 13 .

[0064] It is circuitry in case the output signal from an oscillator (VCO) 54 is a sinusoidal signal, and drawing 12 adds the zero cross comparator 110 and D flip-flop (D. FF) 111 to the part which generates a driving signal among the drive circuits shown in drawing 7 , it omits some components and shows them roughly. In this case, the output signal of an oscillator (VCO) 54 is inputted also into the zero cross comparator 110, and the output (the timing from which the electrical potential difference of the output signal of an oscillator (VCO) 54 was set to "0" is expressed) of the zero cross comparator 110 is inputted into the clock terminal of D flip-flop 111 as a timing signal. Moreover, the output of current value comparator 58A or 58B is inputted into D terminal of D flip-flop 111, and controls switching device 55A or 55C using the output from Q terminal of D flip-flop 111. Consequently, ON / off timing of switching device 55A or 55C synchronizes with the standup of the output signal from an oscillator 54, or falling.

[0065] It is circuitry in case the output signal from an oscillator (VCO) 54 is a square wave signal, and drawing 13 adds D flip-flop (D. FF) 111 to the part which generates a driving signal among the drive circuits shown in drawing 8 , it omits some components and shows them roughly. In this case, the direct input of the output signal of oscillator (VCO) 54X is carried out to the clock terminal of D flip-flop 111 as a timing signal. Moreover, the output of current value comparator 58A or 58B is inputted into D terminal of D flip-flop 111, takes AND of the output signal of the output from Q terminal of D flip-flop 111, and oscillator (VCO) 54X by H bridge driver control section 90, and controls H bridge driver 100A or 100B using the signal. Consequently, switching device 101A - 101D ON / off timing synchronizes with the standup of the output signal from oscillator 54X, or falling.

[0066] Next, how to carry out a low-speed drive using the actuator of this above-mentioned operation gestalt is explained briefly. As mentioned above, the standup and falling take time amount to vibration of a piezoelectric device. This property is used and the desired value of the current which flows to the piezoelectric device at the time of a burst modulation drive is set as a

value lower than the desired value in the case of impressing a driving signal continuously. it is maintained by about 1 law in the range where that is right then where the amplitude of vibration of a piezoelectric device by which a monitor is carried out, as a result the amplitude of vibration of drive **** are small. Consequently, the same drive rate as the case where the electrical potential difference of the driving signal impressed to a piezoelectric device is lowered seemingly is obtained. In addition, since the electrical potential difference of a driving signal is fixed a now case, it is not necessary to make the amplification factor of amplifier adjustable, and circuitry can be simplified. On the contrary, when the amplification factor of amplifier is adjustable, control precision of a low-speed drive can be made high.

[0067] in addition -- explanation of the above-mentioned operation gestalt -- a truss -- although the mold actuator was explained, it cannot be overemphasized that it is applicable to the actuator of others which are not limited to this and used supersonic vibration. Moreover, it constituted from explanation of the above-mentioned operation gestalt so that a chip member might be prepared in a part for the intersection of two piezoelectric devices and this chip member might be contacted to Rota which is a driven member, but it is not limited to this, and you may constitute so that the amount of [of displacement components, such as a piezoelectric device,] intersection may be made to contact a direct driven member.

[0068] Furthermore, although the driving signal was impressed to one of piezoelectric devices, and it considered as the driving-side component and being considered as the follower side component with the above-mentioned operation gestalt, without impressing a driving signal to the piezoelectric device of another side, you may constitute, not being limited to this and impressing a driving signal to each piezoelectric device at coincidence so that the burst modulation drive which controls the timing of impression time amount and the quiescent time which impresses a driving signal may be performed. Furthermore, the number of piezoelectric devices (variation rate component) may not be limited to two, but may be three or more. In that case, you may drive so that at least one piezoelectric device may be made to follow. Furthermore, as a displacement component, it is not limited to the laminating mold piezoelectric device shown in drawing 2 , but what combined magnetostrictor, the piezoelectric device, and the elastic member can be used.

[0069]

[Effect of the Invention] As explained above, according to the actuator of this invention, two or more displacement components are arranged so that the variation rate of each displacement component may be compounded. said variation rate -- the variation rate of a component -- the actuator which drives a driven member by making a driven member carry out pressurization contact of the synthetic part -- it is -- at least one variation rate -- the variation rate which detects the information about the variation rate of a component -- with a detecting element A comparator [at least one desired value / information / which was detected by said displacement detecting element] and the control section which controls the impression time amount and the quiescent time which impress a driving signal to said displacement component using the comparison result by said comparator are provided.

[0070] Moreover, according to the drive approach of the actuator of this invention, the variation rate of two or more displacement components is compounded. It is the drive approach of an actuator of driving a driven member by making a driven member carrying out pressurization contact of the displacement composition part of said displacement component. The impression time amount and the quiescent time which detect the information about the variation rate of at least one displacement component, and impress a driving signal to said displacement component for the detected information using a comparison result as compared with at least one desired value are controlled.

[0071] namely, this invention -- a variation rate -- even if it starts impression of a driving signal for a component -- a predetermined variation rate immediately -- if it is an amount -- ** and a predetermined variation rate -- until it reaches an amount -- fixed time amount -- requiring -- the meantime -- a variation rate -- while an amount increases gradually, even if it stops impression of a driving signal -- immediately -- a variation rate -- an amount -- 0 -- not becoming -- a variation rate -- the property which an amount decreases gradually is used. for example, a

variation rate -- the variation rate of a component -- the time of an amount exceeding desired value -- impression of a driving signal -- stopping -- a variation rate -- when an amount becomes below desired value, by driving for the business which resumes impression of a driving signal, the rate of the impression time amount of the driving signal occupied to all the operating times can be made small, the power consumption of an actuator can be reduced, and a battery life can be developed. Moreover, the same drive rate as the case where an actuator is driven on an electrical potential difference seemingly lower than the electrical potential difference of a driving signal can be obtained by setting up desired value low. Furthermore, since the direction which takes out an output intermittently can use cell capacity effectively rather than a cell takes out an output continuously, it can use cell capacity effectively by supplying a driving signal to a displacement component intermittently.

[0072] moreover, the thing controlled to start impression of a driving signal when said desired value was set to one, impression of a driving signal is stopped when said information becomes higher than said desired value, and said information becomes said below desired value -- a variation rate -- the variation rate of a component -- an amount -- if it puts in another way, the drive rate or output of an actuator can be made into about 1 law.

[0073] Or said desired value is made into the 2nd desired value lower than the 1st desired value and the 1st desired value. By stopping impression of a driving signal, when said information becomes higher than said 1st desired value, and controlling to start impression of a driving signal, when said information becomes said 2nd less than desired value a variation rate -- the variation rate of a component -- while being made to about 1 law within limits which can permit the error of an amount, impression time amount of a driving signal can be shortened further.

[0074] At least one is set up about a component, respectively. or said desired value -- at least -- the 1st variation rate -- a component and the 2nd variation rate -- two variation rates of a component -- A component and the information about a variation rate are detected about a component the 2nd variation rate the 1st variation rate, respectively. said variation rate -- as for the detecting element, desired value was set up -- The information and desired value of a component are compared. said comparator -- the 1st variation rate -- a component and the 2nd variation rate -- a component -- these variation rates -- By said control section's stopping impression of a driving signal, when said information about a component becomes higher than desired value the 1st variation rate, and controlling to start impression to a driving signal, when said information about a component becomes below desired value the 2nd variation rate Even if it is the case where dispersion is in the displacement property of two displacement components etc., drive properties, such as a drive rate of an actuator, can be stabilized.

[0075] Furthermore, the drive circuit of an actuator and control can be simplified by exciting at least one displacement component by vibration of other displacement components among said two or more displacement components.

[0076] furthermore, said variation rate -- the information about the variation rate of a component -- said variation rate -- considering as the information about the amplitude of a component -- a variation rate -- it is easy to detect the information about the variation rate of a component, and detection precision can be raised.

[0077] especially -- said variation rate -- a component -- a piezoelectric device -- carrying out -- said variation rate -- as the information about the amplitude of a component -- said variation rate -- carrying out the monitor of the electrical potential difference of the both ends by detecting the current value which flows for a component using the property of a piezoelectric device -- very -- easy -- a variation rate -- the information about the variation rate of a component can be acquired.

[0078] Furthermore, by synchronizing with the period of said driving signal the impression time amount and the quiescent time which impress a driving signal to said displacement component, it can be lost that the signal of a period with which the periods of a driving signal differ in the standup and falling of a driving signal is impressed, and actuation of an actuator can be stabilized further.

TECHNICAL FIELD

[Field of the Invention] This invention relates to the actuator which used displacement components, such as a piezoelectric device, and its drive approach.

PRIOR ART

[Description of the Prior Art] Before, in the actuator (ultrasonic motor) using a piezoelectric device, the burst modulation drive (intermittent drive) is performed for the purpose of the deployment of speed control and cell capacity.

[0003] For example, the technique of controlling the speed by changing the frequency and duty ratio of a burst signal (alternating-voltage driving signal) is shown in JP,7-89748,B. Moreover, after it changes impression time amount and impression time amount reaches a lower limit until it sets up the lower limit of the continuation impression time amount of driver voltage and impression time amount reaches a lower limit, the technique which controls a rate is shown to patent No. 283116 by by changing the quiescent time. Furthermore, the technique of raising the utilization factor of cell capacity is shown to patent No. 3005865 by by changing the due tee ratio of a burst signal.

EFFECT OF THE INVENTION

[Effect of the Invention] according to [as explained above] the actuator of this invention -- two or more variation rates -- a component -- each -- a variation rate -- the variation rate of a component is compounded -- as -- arranging -- said variation rate -- the variation rate of a component -- making a driven member carry out pressurization contact of the synthetic part the actuator which drives a driven member -- it is -- at least one variation rate -- the variation rate which detects the information about the variation rate of a component -- a detecting element and said variation rate -- the comparison result by the comparator [at least one desired value / information / which was detected by the detecting element], and said comparator -- using -- said variation rate -- the control section which controls the impression time amount and the quiescent time which impress a driving signal to a component is provided.

[0070] moreover -- according to the drive approach of the actuator of this invention -- two or more variation rates -- the variation rate of a component -- compounding -- said variation rate -- the variation rate of a component -- making a driven member carry out pressurization contact of the synthetic part It is the drive approach of an actuator of driving a driven member, and the impression time amount and the quiescent time which detect the information about the variation rate of at least one displacement component, and impress a driving signal to said displacement component for the detected information using a comparison result as compared with at least one desired value are controlled.

[0071] namely, this invention -- a variation rate -- even if it starts impression of a driving signal for a component -- a predetermined variation rate immediately -- if it is an amount -- ** and a predetermined variation rate -- until it reaches an amount -- fixed time amount -- requiring -- the meantime -- a variation rate -- while an amount increases gradually, even if it stops impression of a driving signal -- immediately -- a variation rate -- an amount -- 0 -- not becoming -- a variation rate -- the property which an amount decreases gradually is used. for example, a variation rate -- the variation rate of a component -- the time of an amount exceeding desired value -- impression of a driving signal -- stopping -- a variation rate -- when an amount becomes below desired value, by driving for the business which resumes impression of a driving signal, the rate of the impression time amount of the driving signal occupied to all the operating times can be made small, the power consumption of an actuator can be reduced, and a battery life can be developed. Moreover, the same drive rate as the case where an actuator is driven on an electrical potential difference seemingly lower than the electrical potential difference of a driving signal can be obtained by setting up desired value low. Furthermore, since the direction which takes out an output intermittently can use cell capacity effectively rather than a cell takes out an output continuously, it can use cell capacity effectively by supplying a driving signal to a

displacement component intermittently.
[0072] moreover, the thing controlled to start impression of a driving signal when said desired value was set to one, impression of a driving signal is stopped when said information becomes higher than said desired value, and said information becomes said below desired value -- a variation rate -- the variation rate of a component -- an amount -- if it puts in another way, the drive rate or output of an actuator can be made into about 1 law.
[0073] or the thing controlled to start impression of a driving signal when said desired value was made into the 2nd desired value lower than the 1st desired value and the 1st desired value, impression of a driving signal is stopped when said information becomes higher than said 1st desired value, and said information becomes said 2nd less than desired value -- a variation rate -- the variation rate of a component -- while being made to about 1 law within limits which can permit the error of an amount Impression time amount of a driving signal can be shortened further.
[0074] At least one is set up about a component, respectively. or said desired value -- at least -- the 1st variation rate -- a component and the 2nd variation rate -- two variation rates of a component -- A component and the information about a variation rate are detected about a component the 2nd variation rate the 1st variation rate, respectively. said variation rate -- as for the detecting element, desired value was set up -- The information and desired value of a component are compared. said comparator -- the 1st variation rate -- a component and the 2nd variation rate -- a component -- these variation rates -- Said control section is controlling to start impression to a driving signal, when impression of a driving signal is stopped when said information about a component becomes higher than desired value the 1st variation rate, and said information about a component becomes below desired value the 2nd variation rate. Even if it is the case where dispersion is in the displacement property of two displacement components etc., drive properties, such as a drive rate of an actuator, can be stabilized.
[0075] Furthermore, the drive circuit of an actuator and control can be simplified by exciting at least one displacement component by vibration of other displacement components among said two or more displacement components.
[0076] furthermore, said variation rate -- the information about the variation rate of a component -- said variation rate -- considering as the information about the amplitude of a component -- a variation rate -- it is easy to detect the information about the variation rate of a component, and detection precision can be raised.
[0077] especially -- said variation rate -- a component -- a piezoelectric device -- carrying out -- said variation rate -- as the information about the amplitude of a component -- said variation rate -- carrying out the monitor of the electrical potential difference of the both ends by detecting the current value which flows for a component using the property of a piezoelectric device -- very -- easy -- a variation rate -- the information about the variation rate of a component can be acquired.
[0078] Furthermore, by synchronizing with the period of said driving signal the impression time amount and the quiescent time which impress a driving signal to said displacement component, it can be lost that the signal of a period with which the periods of a driving signal differ in the standup and falling of a driving signal is impressed, and actuation of an actuator can be stabilized further.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, now, the technique in which each above-mentioned conventional technique stabilizes the output of the actuator by burst modulation drive about speed control of the actuator by burst modulation drive or a deployment of cell capacity is not known.
[0005] This invention is made in order to solve the trouble of the above-mentioned conventional example, and it aims at offering the actuator which stabilized the output by burst modulation drive, and its drive approach.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, now, the technique in which each above-mentioned conventional technique stabilizes the output of the actuator by burst modulation drive about speed control of the actuator by burst modulation drive or a deployment of cell capacity is not known.

[0005] This invention is made in order to solve the trouble of the above-mentioned conventional example, and it aims at offering the actuator which stabilized the output by burst modulation drive, and its drive approach.

MEANS

[Means for Solving the Problem] In order to attain the above-mentioned purpose, the actuator of this invention It is the actuator which drives a driven member by making a driven member carry out pressurization contact of the synthetic part. two or more variation rates -- a component -- each -- a variation rate -- the variation rate of a component is compounded -- as -- arranging -- said variation rate -- the variation rate of a component -- The displacement detecting element which detects the information about the variation rate of at least one displacement component, It is characterized by providing a comparator [at least one desired value / information / which was detected by said displacement detecting element], and the control section which controls the impression time amount and the quiescent time which impress a driving signal to said displacement component using the comparison result by said comparator.

[0007] In the above-mentioned configuration, said desired value is one, and when impression of a driving signal is stopped when said information becomes higher than said desired value, and said information becomes said below desired value, it is desirable to start impression of a driving signal.

[0008] Moreover, said desired value is the 2nd desired value lower than the 1st desired value and the 1st desired value, and when impression of a driving signal is stopped when said information becomes higher than said 1st desired value, and said information becomes said 2nd less than desired value, it is desirable [desired value] to start impression of a driving signal.

[0009] At least one is set up about a component, respectively. furthermore, said desired value -- at least -- the 1st variation rate -- a component and the 2nd variation rate -- two variation rates of a component -- A component and the information about a variation rate are detected about a component the 2nd variation rate the 1st variation rate, respectively. said variation rate -- as for the detecting element, desired value was set up -- The information and desired value of a component are compared. said comparator -- the 1st variation rate -- a component and the 2nd variation rate -- a component -- these variation rates -- When impression of a driving signal is stopped when said information about a component becomes higher than desired value the 1st variation rate, and said information about a component becomes below desired value the 2nd variation rate, as for said control section, it is desirable to start impression to a driving signal.

[0010] Furthermore, it is desirable to excite at least one displacement component by vibration of other displacement components among said two or more displacement components.

[0011] Furthermore, as for the information about the variation rate of said displacement component, it is desirable that it is the information about the amplitude of said displacement component.

[0012] Furthermore, said displacement component is a piezoelectric device and it is desirable to detect the current value which flows for said displacement component as information about the amplitude of said displacement component.

[0013] Furthermore, as for the impression time amount and the quiescent time which impress a driving signal to said displacement component, synchronizing with the period of said driving signal is desirable.

[0014] On the other hand, the drive approach of the actuator of this invention It is the drive approach of an actuator of driving a driven member by making a driven member carrying out pressurization contact of the synthetic part. two or more variation rates -- the variation rate of a

component -- compounding -- said variation rate -- the variation rate of a component -- It is characterized by controlling the impression time amount and the quiescent time which detect the information about the variation rate of at least one displacement component, and impress a driving signal to said displacement component for the detected information using a comparison result as compared with at least one desired value.

[0015] In the above-mentioned approach, when said desired value was set to one, impression of a driving signal is stopped when said information becomes higher than said desired value, and said information becomes said below desired value, it is desirable to start impression of a driving signal.

[0016] Moreover, when said desired value was made into the 2nd desired value lower than the 1st desired value and the 1st desired value, impression of a driving signal is stopped when said information becomes higher than said 1st desired value, and said information becomes said 2nd less than desired value, it is desirable to start impression of a driving signal.

[0017] At least one is set up about a component, respectively. furthermore, said desired value -- at least -- the 1st variation rate -- a component and the 2nd variation rate -- two variation rates of a component -- A component and the information about a variation rate are detected about a component the 2nd variation rate the 1st variation rate, respectively. desired value was set up -- The information and desired value of a component are compared. the 1st variation rate -- a component and the 2nd variation rate -- a component -- these variation rates -- When impression of a driving signal is stopped when said information about a component becomes higher than desired value the 1st variation rate, and said information about a component becomes below desired value the 2nd variation rate, it is desirable to start impression to a driving signal.

[0018] furthermore, said two or more variation rates -- at least one variation rate among components -- a driving signal is impressed to a component and it vibrates -- making -- other at least one variation rate -- a component -- said variation rate -- it is desirable to make it excite by vibration of a component.

[0019] Furthermore, it is desirable to detect the information about the amplitude of said displacement component as information about the variation rate of said displacement component.

[0020] Furthermore, it is desirable to detect the current value which flows for said displacement component as information about the amplitude of said displacement component, using a piezoelectric device as said displacement component.

[0021] Furthermore, it is desirable to synchronize with the period of said driving signal the impression time amount and the quiescent time which impress a driving signal to said displacement component.

[0022]

[Embodiment of the Invention] The actuator concerning 1 operation gestalt of this invention is explained. the truss which is an actuator concerning this operation gestalt -- the configuration of a mold actuator is shown in drawing 1 .

[0023] 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B of two laminating molds which have been arranged so that a drive unit may make a predetermined include angle (for example, 90 degrees) mutually as shown in drawing 1 , The chip member 20 joined to the crossover side edge section of 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B by adhesives etc. (driving member), The base member 30 to which it is fixed to by adhesives etc. and the end face section of 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B holds 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B, It consists of pressurization members (elastic bodies, such as coiled spring and flat spring) 45 which generate the welding pressure for making the chip member 20 contact the front face of Rota 40.

[0024] The detail of 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B is shown in drawing 2 . In addition, both are the same configurations substantially. Each piezoelectric devices 10A and 10B carry out the laminating of two or more ceramic sheet metal 11 and electrodes 12 and 13 in which piezo-electric properties, such as PZT (titanic-acid lead zirconate), are shown, respectively by turns, and each ceramic sheet metal 11 and electrodes 12 and 13 are being fixed by adhesives etc. Each electrode groups 12 and 13 arranged alternately are connected to the drive power source 16 through signal lines 14 and 15, respectively. When a predetermined

electrical potential difference is impressed among signal lines 14 and 15, in each ceramic sheet metal 11 inserted into electrodes 12 and 13, electric field occur in the direction of a laminating, and the electric field are the alternately same directions. therefore, as for each ceramic sheet metal 11, the direction of polarization becomes the same alternately (the direction of polarization of two adjacent ceramic sheet metal 11 becomes reverse) -- the laminating is carried out like. In addition, the protective layer 17 is formed in the both ends of each piezoelectric devices 10A and 10B.

[0025] If the driver voltage of a direct current is impressed among each electrodes 12 and 13 according to the drive power source 16, elongation or shrinkage, and each piezoelectric devices 10A and 10B expand in this direction and contract [all ceramic sheet metal 11] as a whole. Electric field are small and it can be considered that the variation rate of the electric field generated among each electrodes 12 and 13 and each piezoelectric devices 10A and 10B is almost linear relation in the field which can disregard the hysteresis like browning.

[0026] On the other hand, if the driver voltage (AC signal) of an alternating current is impressed among each electrodes 12 and 13 according to the drive power source 16, according to the electric field, each ceramic sheet metal 11 will repeat telescopic motion in this direction, and each piezoelectric devices 10A and 10B will repeat telescopic motion as a whole. The resonance frequency of the proper determined by the structure and electrical characteristics exists in each piezoelectric devices 10A and 10B. If the frequency of the driver voltage of an alternating current is in agreement with the resonance frequency of each piezoelectric devices 10A and 10B, an impedance will fall and the variation rate of each piezoelectric devices 10A and 10B will increase. Since the variation rate is small, in order to drive on a low electrical potential difference to that dimension, as for each piezoelectric devices 10A and 10B, it is desirable to use these resonance phenomena.

[0027] The tungsten which was stabilized, and high coefficient of friction was obtained as an ingredient of the chip member 20, and was excellent in abrasion resistance is desirable. As an ingredient of the base member 30, manufacture is easy and the stainless steel excellent in reinforcement etc. is desirable. Moreover, as adhesives, epoxy system resin excellent in adhesive strength and reinforcement etc. is desirable.

[0028] Whether 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B are driven with the AC signal which has phase contrast, respectively, and by crawling again and driving one [a gap or] piezoelectric-device 10A or 10B, it can drive so that the chip member 20 may draw an elliptical orbit or a circular orbit. If this chip member 20 is forced on the cylinder side of Rota 40 pivotable around the predetermined shaft L, it will become possible to change ellipse movement or the circular motion of the chip member 20 into rotation of Rota 40. Or it becomes possible by forcing the chip member 20 on the flat-surface section of a cylindrical member (not shown) to change ellipse movement or the circular motion of the chip member 20 into the rectilinear motion of a cylindrical member. As an ingredient of Rota 40, lightweight metals, such as aluminum, are desirable, and in order to prevent wear by friction with the chip member 20, it is desirable to perform tufftriding, alumite processing, etc. to a front face.

[0029] a truss as shown in drawing 1 -- as the drive approach of a mold actuator How to impress the driving signal which has predetermined phase contrast, respectively to two piezoelectric devices 10A and 10B, and to drive two piezoelectric devices 10A and 10B to coincidence, One of piezoelectric-device (driving-side component) 10A or 10B are driven, and the drive approach of transmitting vibration to which vibration in which the phase was behind [piezoelectric-device (follower side component) 10B or 10A of another side], or a phase progressed can be considered. The latter drive approach is adopted in the actuator of this operation gestalt.

[0030] When driving only one of piezoelectric-device 10A or 10B, the phase contrast of vibration of piezoelectric-device 10B used as vibration and the passive element of piezoelectric-device 10A used as a driver element or 10B or 10A changes with the frequencies of a driving signal. Moreover, the configuration of the locus of the chip member 20 prepared in the intersection of one piezoelectric devices 10A and 10B changes with the phase contrast of vibration of these two piezoelectric devices 10A and 10B according to the formula (formula of Lissajous) of ellipse vibration.

[0031] If it will expand and contract in the direction of electric field, and an electrical potential difference is impressed to a piezoelectric device and tensile force or compressive force will be applied in the predetermined direction to a piezoelectric device as everyone knows, an electrical potential difference will be generated in the direction. Therefore, the vibrational state of a driving-side component and a follower side component can be known by carrying out the monitor of the current which flows with the electrical potential difference generated for the current which flows for a driving-side component, and a follower side component.
[0032] Next, an alternating-voltage (sine wave) driving signal is inputted and driven to one piezoelectric-device (driving-side component) 10A or 10B, and the current value change which flows to each piezoelectric devices 10A and 10B at the time of vibrating piezoelectric-device (follower side component) 10B or 10A of another side is shown in drawing 3 and drawing 4 . Drawing 3 shows the current wave form immediately after beginning to impress a driving signal to a driving-side component (at the time of starting), and drawing 4 shows the current wave form immediately after stopping impression of the driving signal to a driving-side component (at the time of a halt). These current wave forms are detected using the resistance connected to the serial, respectively to each piezoelectric devices 10A and 10B.
[0033] A standup until a driving-side component and a follower side component reach the predetermined amplitude at the time of starting takes time amount so that drawing 3 may show. Moreover, although a driving-side component starts vibration comparatively immediately from impression initiation of a driving signal, time amount is taken for a follower side component to start vibration for a while. Moreover, falling until it decreases a driving-side component and a follower side component to the predetermined amplitude similarly at the time of a halt takes time amount so that drawing 4 may show. Moreover, even if a follower side component has late falling compared with a driving-side component and a driving-side component decreases it mostly, it is still vibrating with the predetermined amplitude. Thus, when driving only one piezoelectric device, in order to use resonance phenomena, the standup of vibration of each piezoelectric device takes time amount, and after a halt of a driving signal carries out fixed time amount continuation of the vibration of each piezoelectric device.
[0034] Next, the burst modulation drive in the actuator of this operation gestalt is explained, referring to drawing 5 and drawing 6 . In each drawing, (a) expresses the driving signal with which the current value which flows to piezoelectric-device 10A or 10B by which a monitor is carried out, and (b) are impressed to a burst signal, and (c) is actually impressed to a piezoelectric device, respectively. In addition, the piezoelectric devices by which a monitor is carried out may be any of a driving-side component and a follower side component.
[0035] Even if a burst modulation drive stops the driving signal impressed to a driving-side component, it uses the phenomenon which vibration of fixed time amount each piezoelectric device maintains. The example of a drive shown in drawing 5 is the case where only one desired value of control is set up, and when the driving signal was impressed continuously, the predetermined value was exceeded, impression of a driving signal is stopped and a current value turns into below a predetermined value further until the current value which flows to piezoelectric-device 10A or 10B becomes higher than a predetermined value, it resumes impression of a driving signal. In the example of a drive shown in drawing 5 , only while the burst signal between below desired value is outputted for the peak value of the alternating current value which flows to the piezoelectric device by which a monitor is carried out and the burst signal is outputted, a driving signal is impressed to a driving-side component.
[0036] Moreover, when impression of a driving signal is stopped when the driving signal was continuously impressed until the current value which is the case where the example of the drive shown in drawing 6 sets up two desired value of control, and flows to piezoelectric-device 10A or 10B became higher than the 1st predetermined value, and the 1st predetermined value was exceeded, and it becomes below the 2nd predetermined value with a current value still smaller than the 1st predetermined value, impression of a driving signal is resumed. In the example of a drive shown in drawing 6 , only while a burst signal is outputted and the burst signal is outputted until it exceeds the 1st desired value from the time of the peak value of the alternating current value which flows to the piezoelectric device by which a monitor is carried out turning

into the 2nd less than desired value, a driving signal is impressed to a driving-side component. Although the actuator is vibrating continuously seemingly by repeating these actuation, a driving signal is not supplied intermittently and the low-speed drive of an actuator and the deployment of cell capacity of it are attained. Furthermore, since it is controlled so that the peak value of the current which flows to the piezoelectric device by which a monitor is carried out becomes fixed within the limits, a rate, torque, etc. of a driven member by the actuator can be stabilized.

[0037] Next, an example of the block configuration of the drive circuit in this operation gestalt is shown in drawing 7 . In the example shown in drawing 7 , a sinusoidal-voltage signal is used as a driving signal impressed to piezoelectric-device 10A or 10B.

[0038] In order to detect the current which flows to each piezoelectric devices 10A and 10B, respectively, series connection of the resistance 51A and 51B is carried out to 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B. The terminal voltage of each resistance 51A and 51B is detected as a sinusoidal current wave as inputted into 1st current detecting-element 52A and 2nd current detecting-element 52B, respectively, for example, shown in drawing 3 and drawing 4 . Each current detecting elements 52A and 52B consist of amplifier, zero cross comma RETA, etc., respectively, and after they shape a sinusoidal current wave in waveform to a square wave, they input a square wave signal into the phase contrast detecting element 53. The phase contrast detecting element 53 consists of an exclusive OR circuit, a low pass filter, etc., and detects the phase contrast of two inputted signals.

[0039] The phase contrast signal of the analog obtained by the phase contrast detecting element 53 is inputted into the A/D-conversion section 61 of the data-processing section (MPU) 60, and after being digital-signal-ized, it is compared with target phase contrast (Ref) by the phase contrast comparator (Comp) 62. The comparison result (it is [target phase contrast and] actually a difference with phase contrast) by the phase contrast comparator 62 is inputted into the D/A transducer 63, and after being digital-signal-ized, it is inputted into a voltage controlled oscillator (VCO) 54. In addition, although I/O control unit (I/O) 64 is formed in the data-processing section 60, the function is mentioned later.

[0040] An oscillator 54 adjusts the oscillation frequency according to the output from the data-processing section 60. The sinusoidal signal with which the frequency was adjusted is inputted into 1st amplifier 56A and 2nd amplifier 56B through the 1st - the 4th switching device 55A-55D, and is amplified by the predetermined amplitude. Each switches 55A-55D shall be turned on if the signal which consists of components, such as a transistor, respectively, for example, is equivalent to high level or "1" is inputted, and it shall be constituted so that it may turn off, if the signal equivalent to a low level or "0" is inputted. In addition, in the following explanation, it considers as a "high-level signal" and a "low-level signal" for convenience.

[0041] The driving signal which the driving signal amplified by 1st amplifier 56A was impressed to 1st piezoelectric-device 10A, and was amplified by 2nd amplifier 56B is impressed to 2nd piezoelectric-device 10B. Thus, it becomes possible by detecting the actual vibrational state of 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B using a current value etc., and carrying out feedback control of the frequency of a driving signal so that it may be in agreement with target phase contrast in the phase contrast of those vibration to make the configuration which asks for the locus of the chip member 20 resemble.

[0042] In addition, switching devices 55A-55D are used in order to control impression initiation and a halt of the driving signal in the case of the change of any [a driving-side component and] to make into a follower side component for any between 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B, and burst modulation control. Moreover, since only one of piezoelectric-device 10A or 10B are driven with this operation gestalt and the piezoelectric device of another side is made to follow, there is nothing of 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B for which switching devices 55A-55D are controlled so that a driving signal is both impressed to coincidence.

[0043] On the other hand, the output of 1st current detecting-element 52A is inputted into 1st peak detecting-element 57A, and the output of 2nd current detecting-element 52B is inputted into 2nd peak detecting-element 57B. Each peak detecting elements 57A and 57B detect those

peaks from a sinusoidal signal as shown in drawing 5 (a) or drawing 6 (a) detected by each current detecting elements 52A and 52B. The peak value signal detected by each peak detecting elements 57A and 57B is inputted into 1st current value comparator 58A and 2nd current value comparator 58B, respectively, and is compared with desired value. As an example, each current value comparators 58A and 58B output a low-level signal, when the peak value of the detected current is higher than desired value (it is either of two desired value depending on the case), and in below desired value, they output a high-level signal. Each current value comparators 58A and 58B compare with predetermined desired value the peak value of the current which always flows to each piezoelectric devices 10A and 10B, and output it to the monitor component change section 70.

[0044] The monitor component change-over section 70 consists of 1st AND circuit 71, 2nd AND circuit 72, and OR circuit 73, the output signal from 1st current value comparator 58A is inputted into 1st AND circuit 71, and the output signal from 2nd current value comparator 58B is inputted into 2nd AND circuit 72. Moreover, 1st AND circuit 71 and 2nd AND circuit 72 are connected to I/O control unit 64 of the data-processing section 60, respectively. I/O control unit 64 outputs a high-level signal to AND circuit 71 connected to the side used as a monitor component among 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B, or 72, and outputs a low-level signal to another side. For example, when using 1st piezoelectric-device 10A as a monitor component, I/O control unit 64 outputs a high-level signal to 1st AND circuit 71, and outputs a low-level signal to 2nd piezoelectric-device 10B. Therefore, even if a high-level signal is outputted from 2nd current value comparator 58B, 2nd AND circuit 72 is not turned on but a low-level signal is outputted from 2nd AND circuit 72. On the other hand, if the peak value of the current which flows to 1st piezoelectric-device 10A turns into below desired value, since a high-level signal will be outputted from 1st current value comparator 58A, 1st AND circuit 71 turns on, and a high-level signal is outputted from 1st AND circuit 71. Since a high-level signal is inputted into OR circuit 73 from 1st AND circuit 71 and a low-level signal is inputted into it from 2nd AND circuit 72, respectively, from OR circuit 73, a high-level signal is outputted to the driver element change-over section 80.

[0045] The driver element change-over section 80 consists of 3rd AND circuit 81 and 4th AND circuit 82, and the output from OR circuit 73 is inputted into 3rd AND circuit 81 and 4th AND circuit 82. Moreover, 3rd AND circuit 81 and 4th AND circuit 82 are connected to I/O control unit 64 of the data-processing section 60, respectively. I/O control unit 64 outputs a high-level signal to AND circuit 81 connected to the side used as a driving-side component among 1st piezoelectric-device 10A and 2nd piezoelectric-device 10B, or 82, and outputs a low-level signal to another side. For example, when using 1st piezoelectric-device 10A as a driving-side component, I/O control unit 64 outputs a high-level signal to 3rd AND circuit 81, and outputs a low-level signal to 2nd piezoelectric-device 10B. Therefore, even if a high-level signal is outputted from OR circuit 73, 4th AND circuit 82 is not turned on but a low-level signal is outputted from 4th AND circuit 82. On the other hand, if a high-level signal is outputted from OR circuit 73, 3rd AND circuit 81 will turn on and a high-level signal will be outputted from 3rd AND circuit 81.

[0046] 3rd AND circuit 81 is connected to 1st switching device 55A prepared between an oscillator 54 and 1st amplifier 56A, and 4th AND circuit 82 is connected to 3rd switching device 55C prepared between an oscillator 54 and 2nd amplifier 56B. Moreover, I/O control unit 64 is connected to 2nd switching device 55B and 4th switching device 55D which were prepared between a ground, 1st amplifier 56A, and 2nd amplifier 56B.

[0047] If a high-level signal is outputted from 3rd AND circuit 81, 1st switching device 55A turns on, and the sinusoidal signal outputted from an oscillator 54 will be inputted into 1st amplifier 56A, will be amplified by the predetermined amplitude, and will be impressed to 1st piezoelectric-device 10A as a driving signal. If a low-level signal is outputted from 3rd AND circuit 81, 1st switching device 55A will turn off, the sinusoidal signal outputted from an oscillator 54 will no longer be inputted into 1st amplifier 56A, and impression of the driving signal to 1st piezoelectric-device 10A will be stopped. In addition, 1st switching device 55A and 3rd switching device 55C do not turn on in coincidence from the configuration of the above-mentioned driver element change-over section 80. Moreover, when 1st piezoelectric-device

10A or 2nd piezoelectric-device 10B is used as a follower side component, respectively, 2nd switching device 55B and 4th switching device 55D are used in order to discharge a charge collected on the follower side component.

[0048] While being able to carry out feedback control of the frequency of a driving signal, using 1st piezoelectric-device 10A or 2nd piezoelectric-device 10B as a driving-side component, and driving another side as a follower side component by such circuitry so that the chip member 20 may draw a predetermined locus, the burst modulation drive which controls impression initiation and a halt of a driving signal can be performed carrying out the monitor of the current which flows for one of components.

[0049] In addition, although the above-mentioned explanation compared this value and desired value using the forward peak value of alternating current as a current value of piezoelectric-device 10A which carries out a monitor, or 10B, it is not limited to this, and if it is the information about amplitude of a displacement component (piezoelectric device), such as actual value, negative peak value, etc. of a current, it is good anything. Furthermore, it constituted so that desired value might be set to either a driving-side component or a follower side component and the monitor of the information about the amplitude of the component might be carried out, but it is not limited to this and one or two desired value may be set to both a driving-side component and a follower side component, respectively, and you may constitute so that the monitor of both a driving-side component and the follower side component may be carried out. A burst signal may be started in that case using the information about the amplitude of a driving-side component, and you may constitute so that a burst signal may be brought down using the information about the amplitude of a follower side component. In that case, I/O control unit 64 should just change by turns the signal inputted into 1st AND circuit 71 and 2nd AND circuit 72 of the monitor component change-over section 70. These application is the same also in the following modifications.

[0050] Next, the block configuration of the modification of the drive circuit in this operation gestalt is shown in drawing 8 . Moreover, the detail of H bridge driver control section in drawing 8 is shown in drawing 9 , and the detail of H bridge driver is shown in drawing 10 . In the modification shown in drawing 8 - drawing 10 , a square wave voltage signal is used as a driving signal impressed to piezoelectric-device 10A or 10B. In addition, since the component which attached the same sign as the circuit shown in above-mentioned drawing 7 is substantially the same, the explanation is omitted.

[0051] Among drawing 8 , voltage controlled oscillator 54X oscillates a square wave signal, and is inputted into H bridge driver control section 90. Moreover, the output from 3rd AND circuit 81 and 4th AND circuit 82 of the driver element change-over section 80 is also inputted into H bridge driver control section 90. H bridge driver control section 90 controls 2ndH bridge driver 100B connected to 1stH bridge driver 100A and 2nd piezoelectric-device 10B which were connected to 1st piezoelectric-device 10A, respectively.

[0052] As shown in drawing 9 , H bridge driver control section 90 consists of the 1st - 4th NAND circuit 91A-91D, and an inverter 92. The square wave signal from oscillator 54X is inputted into the 2NAND-circuit91B and 4th NAND-circuit 91D, after a direct input is carried out to the 1NAND-circuit91A and 3rd NAND-circuit 91C and it is reversed with an inverter 92. On the other hand, the output of 3rd AND circuit 81 is inputted into the 1NAND-circuit91A and 2nd NAND-circuit 91B, and the output of 4th AND circuit 82 is inputted into 3rd NAND-circuit 91C and 4th NAND-circuit 91D.

[0053] Therefore, high-level [the square wave signal from oscillator 54X], when 1st piezoelectric-device 10A is chosen, for example as a driving-side component, when the output from 3rd AND circuit 81 is high-level, a high-level signal is inputted into 1stH bridge driver 100A for a low-level signal from 2nd NAND circuit 92 from 1st NAND circuit 91, respectively. On the contrary, the square wave signal from oscillator 54X is a low level, and when the output from 3rd AND circuit 81 is high-level, a low-level signal is inputted into 1stH bridge driver 100A for a high-level signal from 2nd NAND circuit 92 from 1st NAND circuit 91, respectively. On the other hand, since the signal from 4th AND circuit 82 is a low level, from 3rd NAND-circuit 91C and 4th NAND-circuit 91D, a high-level signal is outputted, respectively. It is also the same as when 2nd

piezoelectric-device 10B is chosen as a driving-side component.
[0054] Next, the configuration of H bridge drivers 100A and 100B is shown in drawing 10 . The 5th which constitutes the bridge circuit for controlling initiation and a halt of impression of driver voltage Vcc to the series circuit of 1st piezoelectric-device 10A and resistance 51A, or the series circuit of 2nd piezoelectric-device 10B and resistance 51B - the 8th switching device 101A-101D, The 1NOR-circuit102A connected to 5th switching device 101A, the 2NOR-circuit102B connected to 7th switching device 101C, It consists of buffers 103A and 103B connected to 6th switching device 101B and 8th switching device 101D, respectively, the 2nd and 3rd inverters 104A and 104B connected to each NOR circuits 102A and 102B. In addition, Buffers 103A and 103B are used in order to adjust the impedance of the switching elements 101B and 101D which consisted of transistors etc.
[0055] While the output signal from the 1NAND-circuit91A or 3rd NAND-circuit 91C is inputted into 1st NOR-circuit 102A through 2nd inverter 104A, the direct input of it is carried out to 2nd NOR-circuit 102B. On the other hand, the output signal from the 2NAND-circuit91B or 4th NAND-circuit 91D is inputted into the 2NOR-circuit102B and buffer 103B through 3rd inverter 104B while it is directly inputted into the 1NOR-circuit102A and buffer 103A.
[0056] The signal from the 1NAND-circuit91A or 3rd NAND-circuit 91C shows the operating state of ON / OFF, and piezoelectric-device 10A of the 5th [signal / from high level, low-level, and the 2NAND-circuit91B or 4th NAND-circuit 91D] according to the combination of high level or a low level - the 8th switching device, or 10B in the following table 1. In addition, signal"X" expresses the signal from the 1NAND-circuit91A or 3rd NAND-circuit 91C among Table 1, and signal"Y" expresses the signal from the 2NAND-circuit91B or 4th NAND-circuit 91D. Moreover, "H" and "L" express that the level of a signal is high level and a low level, respectively, and SW5-SW8 express the 5th - the 8th switching device, respectively. Furthermore, "drive mode" expresses the condition of piezoelectric-device 10A or 10B.
[0057]
[Table 1]

信 号		スイッチ素子				駆動モード
X	Y	SW5	SW6	SW7	SW8	
L	L	OFF	OFF	OFF	OFF	停止
L	H	ON	OFF	OFF	ON	駆動側素子(正方向充電)
H	L	OFF	ON	ON	OFF	駆動側素子(逆方向充電)
H	H	OFF	ON	OFF	ON	従動側素子又は停止

[0058] In the above-mentioned modification, amplify the signal oscillated by oscillator 54X, consider as a driving signal, and this is not impressed to piezoelectric-device 10A or 10B. Since it uses as a timing signal for impressing the driver voltage Vcc to which the signal from the above-mentioned oscillator 54X is supplied by H bridge driver 100A or 100B to piezoelectric-device 10A or 10B The cycle signal by oscillator 54X can be dealt with in digital one, and the configuration of a drive circuit -- amplifier becomes unnecessary -- can be simplified.
[0059] In addition, although the driving signal impressed to piezoelectric-device 10A or 10B is a square wave, since the frequency is near the resonance frequency of each piezoelectric devices 10A and 10B, vibration of each piezoelectric devices 10A and 10B becomes in sine wave. Therefore, although the current wave form where it flows to each piezoelectric devices 10A and 10B also becomes in sine wave, the current which flows for a driving-side component is overlapped on the noise resulting from the rush current by the driving signal. Therefore, it is desirable to carry out low pass filter processing of the current wave form detected by the current detecting elements 52A and 52B.
[0060] Next, it explains the synchronization with the signalling frequency outputted from a burst signal, an oscillator 54, or 54X, and asynchronous. Drawing 11 is a synchronization and a

timing chart in asynchronous, in the signalling frequency (square wave) from oscillator (VCO) 54X, and (b), the driving signal in asynchronous and (d) express the burst signal in a synchronization, and, as for (e), the burst signal in asynchronous and (c) express [(a)] each wave of the driving signal in a synchronization.

[0061] In each drive circuit shown in drawing 7 and drawing 8 , ** it does not take the synchronization of the signalling frequency outputted from a burst signal, an oscillator 54, or 54X, it is asynchronous and is driving. Although the sinusoidal signal or square wave signal of predetermined frequency is continuously outputted from an oscillator 54 or 54X, only while the burst signal is outputted, it consists of each above-mentioned drive circuit so that a driving signal may not be impressed to piezoelectric-device 10A or 10B. If it returns, the driving signal impressed to piezoelectric-device 10A or 10B will serve as a wave which took AND of the signalling frequency of (a), and the burst signal of (b) as shown in drawing 11 (c). Since the signalling frequency outputted from a burst signal, an oscillator 54, or 54X does not synchronize, a different wave-like driving signal from the signalling frequency outputted from the oscillator 54 as shown in (c), or 54X is impressed to a piezoelectric device. In that case, when a signal with a short period like the both ends of (c) is intermingled in a driving signal, there is a possibility that vibration of piezoelectric-device 10A or 10B may become instability a little.

[0062] On the other hand, if the signalling frequency outputted from a burst signal, an oscillator 54, or 54X is synchronized as shown in (d), the wave-like driving signal with the same signalling frequency outputted from the oscillator 54 as shown in (e), or 54X will be impressed to a piezoelectric device. Consequently, vibration of piezoelectric-device 10A or 10B can be stabilized more.

[0063] The circuitry for synchronizing the signalling frequency outputted from a burst signal, an oscillator 54, or 54X is shown in drawing 12 and drawing 13 .

[0064] It is circuitry in case the output signal from an oscillator (VCO) 54 is a sinusoidal signal, and drawing 12 adds the zero cross comparator 110 and D flip-flop (D. FF) 111 to the part which generates a driving signal among the drive circuits shown in drawing 7 , it omits some components and shows them roughly. In this case, the output signal of an oscillator (VCO) 54 is inputted also into the zero cross comparator 110, and the output (the timing from which the electrical potential difference of the output signal of an oscillator (VCO) 54 was set to "0" is expressed) of the zero cross comparator 110 is inputted into the clock terminal of D flip-flop 111 as a timing signal. Moreover, the output of current value comparator 58A or 58B is inputted into D terminal of D flip-flop 111, and controls switching device 55A or 55C using the output from Q terminal of D flip-flop 111. Consequently, ON / off timing of switching device 55A or 55C synchronizes with the standup of the output signal from an oscillator 54, or falling.

[0065] It is circuitry in case the output signal from an oscillator (VCO) 54 is a square wave signal, and drawing 13 adds D flip-flop (D. FF) 111 to the part which generates a driving signal among the drive circuits shown in drawing 8 , it omits some components and shows them roughly. In this case, the direct input of the output signal of oscillator (VCO) 54X is carried out to the clock terminal of D flip-flop 111 as a timing signal. Moreover, the output of current value comparator 58A or 58B is inputted into D terminal of D flip-flop 111, takes AND of the output signal of the output from Q terminal of D flip-flop 111, and oscillator (VCO) 54X by H bridge driver control section 90, and controls H bridge driver 100A or 100B using the signal. Consequently, switching device 101A - 101D ON / off timing synchronizes with the standup of the output signal from oscillator 54X, or falling.

[0066] Next, how to carry out a low-speed drive using the actuator of this above-mentioned operation gestalt is explained briefly. As mentioned above, the standup and falling take time amount to vibration of a piezoelectric device. This property is used and the desired value of the current which flows to the piezoelectric device at the time of a burst modulation drive is set as a value lower than the desired value in the case of impressing a driving signal continuously. it is maintained by about 1 law in the range where that is right then where the amplitude of vibration of a piezoelectric device by which a monitor is carried out, as a result the amplitude of vibration of drive **** are small. Consequently, the same drive rate as the case where the electrical potential difference of the driving signal impressed to a piezoelectric device is lowered

seemingly is obtained. In addition, since the electrical potential difference of a driving signal is fixed a now case, it is not necessary to make the amplification factor of amplifier adjustable, and circuitry can be simplified. On the contrary, when the amplification factor of amplifier is adjustable, control precision of a low-speed drive can be made high.

[0067] in addition -- explanation of the above-mentioned operation gestalt -- a truss -- although the mold actuator was explained, it cannot be overemphasized that it is applicable to the actuator of others which are not limited to this and used supersonic vibration. Moreover, it constituted from explanation of the above-mentioned operation gestalt so that a chip member might be prepared in a part for the intersection of two piezoelectric devices and this chip member might be contacted to Rota which is a driven member, but it is not limited to this, and you may constitute so that the amount of [of displacement components, such as a piezoelectric device,] intersection may be made to contact a direct driven member.

[0068] Furthermore, although the driving signal was impressed to one of piezoelectric devices, and it considered as the driving-side component and being considered as the follower side component with the above-mentioned operation gestalt, without impressing a driving signal to the piezoelectric device of another side, you may constitute, not being limited to this and impressing a driving signal to each piezoelectric device at coincidence so that the burst modulation drive which controls the timing of impression time amount and the quiescent time which impresses a driving signal may be performed. Furthermore, the number of piezoelectric devices (variation rate component) may not be limited to two, but may be three or more. In that case, you may drive so that at least one piezoelectric device may be made to follow. Furthermore, as a displacement component, it is not limited to the laminating mold piezoelectric device shown in drawing 2 , but what combined magnetostrictor, the piezoelectric device, and the elastic member can be used.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] the truss which is 1 operation gestalt of the actuator of this invention -- it is drawing showing the configuration of a mold actuator.

[Drawing 2] It is drawing showing the detailed configuration of the piezoelectric device used in the above-mentioned operation gestalt.

[Drawing 3] In the above-mentioned operation gestalt, one piezoelectric device (driving-side component) is driven, it is drawing showing the current value change which flows to each piezoelectric device at the time of vibrating the piezoelectric device (follower side component) of another side, and the current wave form immediately after beginning to impress a driving signal to a driving-side component (at the time of starting) is shown.

[Drawing 4] It is drawing showing the current wave form immediately after driving like drawing 3 and stopping impression of the driving signal to a driving-side component (at the time of a halt).

[Drawing 5] It is drawing for explaining an example of the burst modulation drive in the actuator of the above-mentioned operation gestalt.

[Drawing 6] It is drawing for explaining other examples of the burst modulation drive in the actuator of the above-mentioned operation gestalt.

[Drawing 7] It is drawing showing an example of the block configuration of the drive circuit in the above-mentioned operation gestalt.

[Drawing 8] It is drawing showing other examples of the block configuration of the drive circuit in the above-mentioned operation gestalt.

[Drawing 9] It is drawing showing the detailed configuration of H bridge driver control section in drawing 8 .

[Drawing 10] It is drawing showing the detailed configuration of H bridge driver in drawing 8 .

[Drawing 11] When synchronizing a burst signal and the signalling frequency outputted from an oscillator, it is the timing chart which shows each signal wave form in asynchronous.

[Drawing 12] It is drawing showing the circuitry for synchronizing a burst signal in case the

output signal from an oscillator is a sinusoidal signal, and the signalling frequency outputted from an oscillator.
[Drawing 13] It is drawing showing the circuitry for synchronizing a burst signal in case the output signal from an oscillator is a square wave signal, and the signalling frequency outputted from an oscillator.
[Description of Notations]
10A: The 1st piezoelectric device
10B: The 2nd piezoelectric device
20 : Chip Member
30 : Base Member
40 : Rota
51A: Resistance
51B: Resistance
52A: The 1st current detecting element
52B: The 2nd current detecting element
53 : Phase Contrast Detecting Element
54 : Oscillator
54X: Oscillator
55A: The 1st switching device
55B: The 2nd switching device
55C: The 3rd switching device
55D: The 4th switching device
56A: The 1st amplifier
56B: The 2nd amplifier
57A: The 1st peak detecting element
57B: The 2nd peak detecting element
58A: The 1st current value comparator
58B: The 2nd current value comparator
60 : Data-Processing Section
61 : A/D-Conversion Section
62 : Phase Contrast Comparator
63 : D/A Transducer
64 : I/O Control Unit
70 : Monitor Component Change-over Section
80 : Driver Element Change-over Section
90 : Bridge Driver Control Section
100A: The 1st bridge driver
100B: The 2nd bridge driver
110 : Zero Cross Comparator
111 : D Flip-flop

[Translation done.]